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ABSTRACT

These proceedings contain eight presentations: "Welcome from the Dean" (P. David Pearson); "Introduction" (Scott Johnson); "The Changing Workforce" (Alan McClelland); "The Changing Workforce: Implications for Secondary School Programs" (Franzie Loepp); "The Changing Workforce: Implications for Community College Programs" (Daniel Hull); "The Changing Workforce: Implications for Private Sector Programs" (Joe Hill); "Projection for the Factory of the Future" (Stephen Lu); and "Closing Comments" (Scott Johnson, Rupert Evans). Presenter biographies, the symposium agenda, and list of participants are appended. A final report describes the project that developed the symposium. It discusses symposium development and an ethnographic study of existing vocational curriculum and instruction to determine if they lead to the development of competencies needed by workers of the future. Two project products are described: symposium proceedings and research findings that document current instructional practice in advanced technology programs in Illinois community colleges. Product abstracts are attached. (YLB)

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Advanced Technology and the Workforce: An Evolving Agenda for Instructor Preparation

**Illinois
State Board of
Education**

Adult,
Vocational and
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Advanced Technology and the Workforce: An Evolving Agenda for Instructor Preparation

Proceedings of the
Eleventh Annual
Rupert N. Evans Symposium
on Vocational Education

Editors

Scott D. Johnson
John A. Evans

Department of
Vocational and
Technical Education
College of Education
University of Illinois
at Urbana-Champaign

Illinois State Board of Education

Thomas Lay Burroughs
Chairman

Robert Leininger
State Superintendent
of Education

Department of Adult, Vocational and Technical Education

Vocational Education
Program Improvement
Section

May 3-4, 1990

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TABLE OF CONTENTS

WELCOME FROM THE DEAN
Dean P. David Pearson 1

INTRODUCTION
Scott D. Johnson 3

THE CHANGING WORKFORCE
Alan L. McClelland 7

THE CHANGING WORKFORCE: IMPLICATIONS FOR SECONDARY SCHOOL PROGRAMS
Franzie L. Loepp 25

THE CHANGING WORKFORCE: IMPLICATIONS FOR COMMUNITY COLLEGE PROGRAMS
Daniel M. Hull 37

THE CHANGING WORKFORCE: IMPLICATIONS FOR PRIVATE SECTOR PROGRAMS
Joe Hill 53

PROJECTION FOR THE FACTORY OF THE FUTURE
Stephen Lu 63

CLOSING COMMENTS
Scott D. Johnson 83
Rupert N. Evans 86

MISCELLANEOUS SYMPOSIUM MATERIALS
Presenter Biographies 89
Symposium Agenda 92
List of Participants 95

WELCOME FROM THE DEAN

P. David Pearson

If you are asked to host a symposium named in honor of Rupert Evans, it is an honor in and of itself. Rupert, as most of you know, spent many, many years as Dean of the College of Education. It is my opinion that he is largely responsible for moving it from a relatively small collection of teacher educators and researchers to a much larger and broad-based college with a clear position of national prominence. What Rupert did was make us the kind of college that befits the Land Grant Mission of the University of Illinois.

To be asked to welcome you to the symposium sponsored by the Department of Vocational and Technical Education in our college doubles the honor. I do not know exactly when the department was founded, but I can tell you that ever since my days as a graduate student at the University of Minnesota, I have known of the department's prominence. Occasionally, Minnesotans even spoke with awe in there hearts when they talked of Illinois. As Dean, I am pleased to share with you the good news, if you have not heard it already, that the department continues its reputation of prominence. In a recent national survey of departmental experts within colleges of education within research universities, our Department of Vocational and Technical Education was ranked second in the nation. Those of you who know our faculty and students, I am sure, are not surprised at this news.

To be asked to welcome folks to the symposium on the topic of Advanced Technology and the Workforce, especially one that focuses on the issue of preparing teachers for that workforce, triples the honor on me. Not only in my role of Dean but even perhaps moreso in my role as researcher interested in the development not of functional literacies, but, rather, of the critical and thoughtful literacies needed to solve the ethical, social, and economic problems imposed by a technologically advanced society. Because of this, I find these issues fascinating, challenging, and I think, above all, critical to our society's survival.

I am not going to give you the "let's catch up with the other industrialized nations" argument (although, I respect that argument); I am going to argue that we need to address the issue of preparing a workforce for a technologically advanced society for the sake of the workers themselves. Many are so ill-prepared to contribute to such a society that they cannot even share in "the mediocre life," let alone the good life.

Certainly I want us to keep our competitive edge. I would never dismiss economic self interest as a primary motive for marshalling the societal resolve we will need to solve these problems in the workforce. I also want us to develop a technologically more literate, more advanced, and more creative workforce. Our citizenry has a right to take advantage of the opportunity that our free society affords. Without large numbers of highly qualified, highly adaptable, and technologically capable workers we will lose both the economic and ethical battles.

Let me close by noting how pleased I am as Dean to see program participants who are representatives of public education, government, and industry all assembled here together. That kind of collaboration is, in my view, needed not only in technology education but, I would argue, in almost all programs of professional education. Thank you for providing a good model of collaboration for the rest of us to follow.

I regret I will not be able to spend all morning with you. I do have to leave sometime mid-morning to solve. . . I can't remember. . . Either it is the crisis that was there when I left or the one that should be there when I get back to campus.

INTRODUCTORY COMMENTS

Scott D. Johnson

I would like to start by giving you some thoughts concerning this symposium. This symposium resulted from a project funded by the Illinois State Board of Education. That project, titled *Sophisticated Technologies*, has looked at the impact of technology on the workforce. We have been examining literature as well as interviewing and surveying employers to identify the types of people they require. We know that the work place is changing rapidly. Our presenters are going to talk about some of those changes.

Technology has changed the work place completely. There is greater sophistication and complexity. Micro-electronics and miniaturization of the equipment have generated a completely different environment than what we have been familiar with.

One of the characterizations of the work place is that there is much more emphasis on mental work. There is less emphasis on physical work. That means that machines are doing the labor and people are doing the thinking. That is quite a change from the past.

Let me give you an example of how industry has switched from physical to mental work. The Diamond Star automotive factory in the Bloomington-Normal area is one of the most advanced automotive plants in the world. They have tremendous robotic and automated facilities. As a truck pulls up to a bay in the rear of the factory, huge rolls of steel are removed from the truck and placed into inventory by a robot. Within an hour, another robot will prepare that steel for the automated die press. Fenders, hoods, and roofs are prepared for inventory. Pieces are then removed from inventory and placed on an automated vehicle for storage at a separate location. Those parts are selected as needed. Only when quality control evaluates the product is the steel touched by human hands. Diamond Star has changed a labor intensive task to an automated manufacturing process.

What we are seeing is a need for workers to become much more adaptable. The work place is changing rapidly and people must change with it. We know the role of technology in the work place will be much different in the future.

We have been studying many of the workforce competency reports that have come out. Just as with the education reform movement, reports dealing with the workforce have been generated, one after the other. We have *Workforce 2000: Workers for the 21st Century* by the Hudson Institute, *Shaping Tomorrow's Workforce* by the National Alliance of Business, *Building a Quality Workforce*, a joint project between the Departments of Labor, Education, and Commerce, and one that just arrived yesterday, *Productive America: Two Year Colleges Unite Improving Productivity in the Nation's Workforce*, a joint project between the National Council for Occupational Education and the American Association of Community and Junior Colleges. The one most sited of all recent reports is *Workforce Basics: The Skills Employers Want* by the Department of Labor and the American Society for Training and Development. All of these reports address the worker of the future.

According to these reports, employees of the future will require positive attitudes, motivation, self-direction, and good work habits. Basic academic skills is another requirement. These will deal with reading, computational skills, and written and oral communication skills. The three Rs will not be enough. Cognitive skills are an important area of emphasis. Creative skills, critical thinking skills, problem solving skills, and decision making skills are examples of the cognitive skills required. Teamwork as well as, interpersonal skills will be necessary. People will not work in isolation. We are going to have a workforce that derives from many cultures. This will require a cross cultural understanding of people.

It is important not to assume a lessening of technical knowledge and skill. When you review these reports you will notice that technical skills are not emphasized. Part of the reason they are not emphasized is that technical skills are a given to most employers. When you talk about academics and basic skills, employers are thinking about something else. Basic skills to an employer are technical skills. Technical skills, computer skills, and scientific knowledge are the basic requirements for productivity.

Finally, we have transferable skills. The future worker must be flexible. They are going to have to be adaptable. They are going to have to be able to perform in many different areas. As *Workforce Basics: The Skills Employers Want* states, the most important skill is the ability to learn. Without the ability to learn nothing else will be very useful.

All of the skills that I have mentioned and that are detailed in all of these reports are important. As technology and the work place change, the broader skills become more important. People need to learn much more quickly. They need to be adaptable. They need a broader set of skills.

That brings me to the issue we are attempting to deal with at this symposium. If we are going to require different kinds of workers, what kinds of instructors will be needed to prepare those workers? In other words, what are the competencies that instructors need to provide students with the skills and knowledge required by employers? Do we really know how to teach multi-cultural skills? How do students develop those? Do we know how to teach creativity? Do we know how to teach problem solving? Those are important skills that instructors must teach. Certainly we can teach the technical skills. We have been doing that for many years. These broader skills may require new types of instruction. What are the skills and attitudes the future instructor will require for effective instruction? How will the instructors become prepared? Many of us are interested in the preparation of instructors for secondary schools, community colleges, and private sector training. How should those instructors be prepared?

THE CHANGING WORKFORCE

Alan L. McClelland

I graduated from here in 1950. That is older than most of you. In fact, that is an absolute key point to me in thinking about some of these things. I received my Ph.D. in Chemistry here at Illinois. I went over to England on a Post-doctoral fellowship and that experience points out some of the changes taking place. When we went to England, just coming out of graduate school, we were very short of funds. We had to get the cheapest transportation to England. At that time, it cost about four times as much to fly to Europe as to take the steam ship. Everything has reversed since then. It is now much cheaper to fly to Europe. You all know the changes that have taken place in transportation.

Another interesting illustration of change is when we arrived in England we found that rationing was still enforced. Cheese, eggs, butter, sugar, candy, a variety of other things were still rationed. The British economy was still trying to recover from the Second World War. When we moved to the continent we found that all you had to do was wave the American dollar and you could have almost anything you wanted. Where are we now? The U.S. is the biggest debtor nation in the world. The American dollar is no longer the strongest currency in the world. There has been a tremendous amount of change. I am not going to belabor this point any more. You all know how much change there has been. That is the absolute key thing that we must always keep in mind. There is nothing we can do about this. I am sure the Romans talked about the same thing. You can be very sure of this, whatever it is that we need to do right now will be very different from what we will need to do ten, twenty, or forty years from now.

One of the crucial messages that we keep forgetting, and we've have got to keep it in the forefront, is that we need to prepare people to live in a changing world. I think that says a great deal about the kind of education we need to give them. It is not a question of learn this, walk out the door, and why bother with things you may never need the rest of your live.

I had the pleasure of coming out here last night and got up for breakfast this morning. There were only a few of us at breakfast this morning. I was dressed casually for breakfast and my fellow speaker, Dan Hull, was impressed by that. He was convinced we should stay casual for the day. Rather than apologizing for not being properly dressed in a coat and tie, I began to realize that maybe that had a message to it. I think the time has come when we have to get back to our shirt sleeves and begin to face some of the down to earth, brass tack, nitty gritty problems in America. That is where the problems are and that is from where the solutions have to come. That is what education is all about.

Education is not about what happens in esoteric conferences like this. It is about what happens in the classrooms. It is what happens between the teacher and the student and whatever they are talking about. So I'm kind of glad to be able to use this as a symbol of getting back to brass tacks.

One of the things you will always find at a conference like this is that someone always takes a speech away from you ahead of time. What you will find is that we keep reiterating the same thing. I think it means that they are right. If so, we have to decide what we going to do something about it.

One of the things that I want to do is heavily dependent on another report. Now if there is anything America has really gotten good at, we are the world leaders at producing reports. We pile them up and pile them up and pile them up. Every time someone comes out they say, "We ought to do a study on ... and write a report." Well, someday someone has got to decide to use some of the things in these reports and not just write another report. Perhaps I am going to fall into that trap and use as my bible in my talk today what I think is one of the most profound reports that has come out in this era of reports. I hope you are familiar with it, if not, I urge you to get familiar with it. The full story is in this book titled *Made in America: Regaining the Productive Edge*. The authors, just so you can get a copy of it, are M.L. Dertouzos, who is professor of electrical engineering and computer science at MIT, Richard K. Lester who is professor of nuclear engineering at MIT, and Robert M. Solow who is a professor of economics at MIT and a winner of the Nobel Prize for Economics (ISBN 0-262-04104100-6).

This is a report on the "MIT Commission on Industrial Productivity". The faculty and administration at MIT did what they do apparently only very occasionally, like only every twenty-five years or something. They put together a group of MIT faculty and staff to look at the question of decline in American industrial productivity. They came to I think, a very sound set of conclusions. There is also a very good summary of this in the June 1989 issue of *Scientific America*. That summarized the study very nicely and it is a good starting point but you ought to get the book and read the whole thing in detail.

I couldn't agree more with Dean Pearson on the place of industrial productivity and industrial competitiveness in our whole scheme of things. To me that isn't a very justifiable end purely in itself. Even though my background is in the business world, I think this emphasis on just making money as an end in itself is now and always has been a very narrow and not very justifiable goal. On the other hand it is having a sound economy, that lets us have the latitude to deal with so many of the issues that are important to us today.

Health care primarily requires a society that can afford to pay for it. We need to have a society that is economically strong enough so that we can afford to make some decisions which may have some short term economic costs by passing long term benefits. For example, take the spotted owl situation in Oregon. They are presently ordered to stop logging in a certain area to save that particular species of owl. Compare the context in which we can look at a question like that versus the argument down in Brazil on preserving the Rain Forest. You really have a great many people down there who live in utter poverty. It is a different question telling them you can't cut down these trees to benefit your own economic situation. The State of course has to act if you want to save the Rain Forest. So, it is a healthy economy that can effectively face a lot of these social, environmental, and ethical issues. I think it is very important that we look at the question of industrial competitiveness but, we need to look at it as a means to an end and not as end in itself.

This book is the best guide, I think, to what we need to do in terms of industrial competitiveness in today's world. Let me just give you a little bit about their study and their conclusions. I strongly urge you to read it and study it and draw your own message from it. Their conclusions were presented in a series of graphs. They identified eight major industries: automobiles, chemicals, commercial aircraft, consumer electronics, machine tools, semiconductors, computers and copiers, steel and textiles. They looked at our competitive position in the world in those eight industries which account for about half of all U.S. exports and imports over the last fifteen years. Six of those eight industries are in a position of a trade deficit now and steadily increasing trade deficits. Two of the industries, and I'm proud to say one of those is chemicals, chemicals and commercial aircraft have maintained the positive trade balance through these fifteen years. In fact, that positive trade balance is actually increasing. From these detailed studies of these industries they have drawn a number of conclusions which are of great importance. Let me just quote some of the things they say here. These quotes are out of the *Scientific America* article. They say,

> If the unpalatable trends in industrial performance are real, and we believe they are, the U.S. has reason to worry. Americans must reduce well if Americans are to live well. Sluggish growth in U.S. productivity is barely sufficient to sustain an improvement in the nations standard of living. Real wages, in fact, have hardly increased since the early seventies. That in itself would be a concern regardless of what is happening in the rest of the world. As it is, the more dynamic productivity performance of other countries is also resulting in a relative decline in the U.S. standard of living.

So we really do have a problem.

> From the shop floor to the board room, the commission was able to observe recurring patterns of behavior and draw certain conclusions about the most important micro-level factors that

> adversely effect the U.S. industrial performance. The verdict is that U.S. industry shows systematic weaknesses that are hampering the ability of many firms to adapt to a changing international business environment. In particular, the commission observed six such weaknesses: out dated business strategies, the neglect of human resources, failures of cooperation, technological weaknesses in development and production, government and industry working at cross purposes, and short term horizons.

One of the very good things about this report is that they do not say, *the* answer is such and such. They look at a variety of issues, all of which need attention. They give us some very good guidance on those issues. Let me quote a little more.

> The American industry of the 1950s and 60s perused flexibility by hiring and firing workers who had limited skills rather than by relying on multi-skilled workers. Worker responsibility and input progressively narrowed and management tended to treat workers as a cost to be controlled not as an asset to be developed. Trading practices in the U.S. have been consistent with that strategy. Workers often received limited training while on the job. Typically it amounts to watching a colleague at work. Even in firms offering organized training programs, plant training is usually short and highly focused on transmitting specific narrow skills for immediate application. In other countries we observed the greater inclination to regard firms as learning institutions where, through education and training, employees can develop breadth and flexibilities in their skills and also require a willingness to learn new skills over the long term. In a system of mass production of standard goods, where cost matters more than quality, the neglect of human resources by com-

> panies may have been compatible with good performance. Today it appears as a major part of the U.S.'s productivity problem.

Now, to me, that means exactly what all of you are concerned with. How do we prepare workers who will be able to operate in the new style of industrial activity which we are going to have to come to? I am one of very few people who has come to the National Science Foundation from industry. I see my role as being a burr under the saddle. I am not at all hesitant to express opinions about what might need to be changed or what is wrong. One of the things that I am very conscience of is a great many of the failures in America today are industry's fault. There has been far to much of this business of industrial people and business people saying, "All the fault is in the educational world." When you read this book, which is a very careful study, you will find that a great share of the difficulty is that industry has gotten into a number of bad practices. We are going to have to change those practices in industry but, we do need to tie those changes in with changes in education. It is absolutely imperative that we cooperate on redefining the role of the American worker, and the education necessary to be an American worker in the future.

As personal proof that this is happening, I called up a good friend of mine and one of the great prides of my work at DuPont. I started out as a research chemist in the laboratory and then got into personnel recruiting. One of the things I did was talk to the people in our central research department who did not have Ph.D.s, about what their futures might be. I pointed out to them that without the Ph.D. at the central research at DuPont you are not going to become a senior researcher. You are not going to become a manager. What are you going to do for the rest of you career? One of the people I did that with was a young woman by the name of Sue Ladchick. She had a B.S. in chemistry and started in our library before becoming a research assistant with some of our senior researchers. She was very good. She liked it. I had a hard time getting her to take a look at something else. Finally she moved to our employee relations department and did a little recruiting. Then, I got her involved in labor studies. She is now the first female plant manager in the history of the DuPont

Corporation. She is a manager of a fifteen hundred employee Dacron polyester plant down in Cape Peer, North Carolina. That is one sign of the change that is taking place. There truly is a difference in the opportunity for women. A true falling of those barriers that have been with us in the past.

One of the things we need to take account of in vocational education, technical education, all kinds of education, is that things really are changing in terms of opportunities for women.

Anyway, I called Sue to find out what is going on in this plant. It confirms everything that this study says needs to be done. I am proud that the DuPont company is doing a lot of it. For example, in that plant they used to have nine layers of employees from the plant floor employees to the plant managers. They now have four. They have cut out the middle members of management. They have gone to the formation of a team of the plant floor workers with one member being leader and rotating that position. They look to that team to solve many quality, safety, and productivity problems.

I asked her, "What are you looking for in plant employment these days?" She said, "We look for some basic skill, reading." She said, " We have a problem." In North Carolina there are, unfortunately, a large number of people who cannot read. So, that basic skill is important. She looks for mathematical skills. In other words, just being able to handle numbers. I talked also to the plant manager, the first black plant manager in DuPont company history, in Chattanooga, Tennessee. He said, "Our biggest challenge is to teach our employees the concept of statistical quality control." They want everyone in the plant to understand statistics and statistical quality control. So basic mathematics, yes, is very important. But then, they are looking for characteristics like leadership, problem solving ability, as well as the ability to work together in teams.

Sue's plant sends the plant floor operators out to customer plants to identify product quality problems. They return to the plant reporting any mistake and effect on the customer's client as well as advising the need for its correction. So the emphasis is on having people who can understand, who can think, who can solve problems, that really has not changed. She points out that physical ability, strength particularly, is relatively unimportant anymore. It is a process control job. As Scott Johnson has already pointed out, they are doing things with machines now. People now need to be able to operate complex equipment rather than just pick it up with their own two hands. One of the other things she said that is absolutely crucial is investing in people now. They do a great deal of internal training. They run programs now in such things as leadership, not just in how to operate such and such a machine. She liked a quotation that a consultant of theirs used in running some of these training programs. He said,

> American industry used to operate, some of it still does, on the military model. The General says, "Do this, don't think about it, just do this." What American management is now beginning to say is, "This is the problem we need to solve, think about it and come up with a solution."

They were having groups of plant floor employees come up with the solution rather than imposing the solution from above. What they are finding is they often get a better solution. So there really is a fundamental change going on in American industry today. Maybe I'm a little prejudice, but the fact that these changes are taking place in the chemical industry and the chemical industry is one of the few American industries that has maintained its world competitiveness, I think is not coincidental.

I spoke this year to a group over in Iowa. Representatives from all the area community colleges were getting together to establish the curriculum in advanced manufacturing technology. We met in Ames and they took us to visit a company there called Sunstran. They have been there a long time. They are a major producer of hydraulic transmissions for everything from the huge Caterpillar earth moving equipment down to a lawn sized tractor. A couple of interesting things about that. First, Sunstran is no longer Sunstran, it is Sunstran-Saubr. It has been acquired by the West German company. Partly as a result of that acquisition, they have been changing there method of operation. Exactly the kinds of ways that Scott Johnson was talking about with the Diamond Star plant. They have gone to "just in time" inventory both on their raw materials coming in and on their shipment out of products. To achieve that, they have put in a whole line of milling centers which process the big castings that they bring in to make these things. Those milling centers are set up so that each action can be ordered by the operator. In other words, every one that is made can be different from the previous one. They can have a schedule. We need one of these, two of these, three of these, and one of these , and so on. Every day they can be processed that way rather than making a batch of 1000 of a particular kind. Those are the kind of changes taking place in American industry.

The horrendous thing, the thing you need to throw back at any industrialist who starts getting a little too pompous about the problems in education, and why don't you follow the directions of industry, those changes came from outside this country. American industry has gotten arrogant, lazy, narrow in its viewpoints, and we let other people take the lead in manufacturing productivity away from us. That is one of the main points the MIT study makes.

There was an interesting article in the *Wall Street Journal* this week. I love to read the *Wall Street Journal*. There are all kinds of interesting things that one picks up. Cincinnati Millicon appointed a new president. The key thing I was intrigued by was that they have lost a lot of their business to the Japanese. Their profit margins have narrowed, and so forth, despite the fact that they have done a great deal of development of sophisticated new machines. It has not quite fit the market needs. But anyway, in there own words, it says,

> Millicon is moving to a focused factory approach where each factory specializes in one kind of machine such as lathes or machine settings. The change from a bureaucratic highly centralized organization responsible for all types of machine tools and robots is intended to increase efficiency and bring the people who design and manufacture machines into closer contact with the buyer.

That is a key point in this MIT study.

They talk about the American over-the-wall approach to product development in manufacturing. By that they mean over here you have a research group. They do some research and write a nice paper on it and throw it over the wall to the product development people. The product development people say, "Hey, that's interesting." So they develop a concept for a new product. Then, they throw that over the wall to the design people. Then they say, "Ok, we are going to design this new product. " So then, they throw it over the wall to the manufacturing engineer who says. "Ok, we will decide how its going to be made." Then they throw it over the wall to the production people and say, "Make it." They don't talk all the way down the line. What is happening is this removal of layers of management. It requires a great deal more coordination up and down the line. You have got to have coordination with your suppliers. You have got to have coordination with your salespeople. You have got to have your product design and your manufacturing capabilities work much more successfully. That requires people to work together to a much greater degree than they have in the past. This is all the way up and down the line. From the top of the company down to every worker on the plant floor. This is where I get to make a few suggestions to education even though industry has lots of faults of its own. We do need to correct all of those, there are some things we could change in education too.

A couple of interesting things here. One is we are terribly committed in education to *the* teacher running the class. So the students for years go through school where you've got *the* teacher designing, and running the course. Telling students what to do. Judging themselves. Then we expect them to walk out and work in teams and be highly cooperative. They have lived with the non-team model all those years through school.

One of the nicest articles I've come across in a long time, this very definitely bears on our topic today, is in a magazine that I'm sure you are familiar with; *Ties*, which is published by Drexel University. This is a March/April, 1990 article in here on technology education, "Links to Other Disciplines." It has got a beautiful little story about Oak Hill High School in Wales, Maine.

> ...however, the challenge has been met with much success for the program and more and more

> people and students. Technology teacher, Mark Kendlemeire and science department chairman and physics instructor Tom Ustach had been working for two years to broaden the physics experience for students, and at the same time moving students closer to technological literacy. For the second year physics classes are team taught with laboratory experiences being technology based while addressing the concepts common to physics at the secondary level. The physics instructor has the primary responsibility for the class including attendance and educational concepts to be addressed, overall evaluation, and much of the supervision. The technology instructor participates in these classes in leu of monitoring study hall.

Which I am sure he is glad to do.

> He often attends the classroom sessions to lead the discussions and provide information linking activities to technology. He also works with the physics instructor to develop technology learning activities with technology concepts of the units to surface or to be discovered.

That makes a lot of sense. If we want students to go out, to be able to work in teams and cooperate, we need to give them models. We've done a lot of talking in recent years about group learning. Students working together in groups. But how often do we show them teachers working together in team teaching? Effectively showing them how cooperation can give you a whole which is greater than the sum of its parts.

I am very pleased and proud to have been able to be involved in funding a program up at Northern Illinois University with a professor, someone you may know, Jule Scarborough, who is in the Department of Technology, College of Technology and Engineering at Northern Illinois. We funded a project for $400,000 to develop new physics teaching units. Jule's approach, which I think was a beautiful one, is to form teams in each school district. She identified six school districts ranging from the Chicago school district, an inner city school district, to Moline. A team consisted of three people: the principal, a physics teacher, and a technology teacher. They worked together to develop new physics teaching materials. One of the fascinating things about it, is the reports back from various people in physics departments in universities. They heard that the National Science Foundation funded a project to develop new physics teaching materials that did not involve a physics professor. Had we lost our mind? I said, "No, I think we are going to get something new and imaginative out of it." So, the concept of bringing different groups together, who traditionally haven't talked to one another, is absolutely crucial to this environment. It fits in with what we want students to do after they get out of school. It deals with what I think is the biggest problem in the teaching of technical courses and that is the revision of what is truly a continuum into a bunch of several little pieces operating independently of each other. Actually, despite the fact that I am a Ph.D. in chemistry and came out of that world, I blame the science departments for this far more than the Colleges of Education. I think the Colleges of Education have done a better job of trying to integrate than the science departments who specialize in isolation and separation. I think the concept that we all need to really buy in to, really need to think about, really work on, is the concept of the continuum of technical education and the continuum of technical education over into the business side. You know all these titles (chemistry, physics, biology, electrical engineering, chemical engineering) are all human inventions. That molecule sitting there doesn't know whether its a chemical molecule or a biological molecule or whether a chemical engineer is going to massage it or a chemist . Science in the real world is a continuum. It is only the artificial division of that continuum by human beings that has resulted in some very serious gaps. Let me give you one little personal story that I think illustrates a key point here.

My oldest son, Stephen, who is now in his early forties, is a geologist with the West Virginia Geological Survey. He took a Bachelors Degree in Geology at Brown University. He took a

Masters Degree in Geophysics at Iowa. When he was near the end at Iowa and he was out looking for jobs. He was interviewed by a consulting company in Pittsburgh, Pennsylvania. This company was founded by a professor at Carnegie-Mellon. They have become the leading consulting company on the application of geology construction problems in the country. This was sixteen, seventeen, eighteen years ago now. They asked Steve lots of questions about geophysics because what they wanted him to do. They wanted him to check sites at which nuclear power plants were to be built to make sure that the nuclear power plant wasn't sitting on a geological fault. They asked him lots of questions about geophysics and he knew geophysics very well. He got to the top guy in the firm, the last interview of the day, this is the owner of the firm, the man who makes the decision on who to offer the job to. I'm sure it got back to him that Steve new his geophysics. He did not ask him anything about geophysics. He said, "Well, you are going to be out in the field running all these experiments. Suppose your instruments break down. What are you going to do? Come back to the office and wait here three weeks while they get repaired?" Steve said, "Well, I'd repair them myself in the field." The man said, "Well, on what basis do you think you could do that." Steve said, "Well, at Brown, I had a year course in electrical engineering for non-majors." The guy said, "Fine, you're probably versed in theory, that's good." "Of course, that won't teach you how to repair an instrument." Steve said, "At my high school in my senior year, I had a year course in electronic shop." The guy's eyes lightened. He smiled. He asked Steve about three questions about that course and offered him a job. The point I think here is that we need a whole spectrum of technical education. Each person can choose out of that spectrum those things that will be useful for him. I would argue that in today's world almost all people are going in to be involved in some kind of technical activity. I don't care at what level, a hands on knowledge of electronics, knowledge of computer capability, some chemistry, some material science is imperative. We need to break down these divisions between what we call vocational education and science education and recognize that there is a continuum. Most people need both. I think *Principles of Technology* is a beautiful example of just that. It is taking the practical hands-on side on one hand and, combining it with the fundamental understanding of the principles of physics on the other. Providing an education that I think will serve a wide variety of people well.

I have told all kinds of people and said it in public speeches, if I knew a kid who wanted to go to college and major in science or engineering, even if that science was going to be physics, I would say if your school offers *Principles of Technology*, you take *Principles of Technology*. If you also have time, go ahead and take traditional college prep physics. If you don't have time, don't worry about it. Even if you become a physics major you are going to learn all that in college anyway. And anyway, it is the most out of date, unmotivated course imaginable. Let me give you a couple of figures to support my statement.

I think that the science people have almost killed a couple of the sciences by their stubborn aversion to bringing the applications of science into the teaching of science. I will argue that for almost any student it is the application of science which initially gets the student interested in the field. Different students can go different depths into the field but, it is the application which is the salesmanship.

This is a little off our topic but, I think it illustrates my point. Kids in their schooling, and this is perfectly true of college students, are looking for one or both of two things; a job and career after they finish school and/or intellectual excitement, something stimulating. Something that they can find and get interested in. Bachelor degrees in Engineering are clearly rising the fastest of all. The reason is that there are jobs in engineering. It is the best job oriented field in school. Now, there is also plenty of intellectual excitement. I think anybody would agree that the job opportunity out of engineering is one of the major things that draws people into it. Degrees in biological science went up in the past because of the intellectual excitement. It started falling off in 1976. Obviously the fall off started four years before that when kids in their freshman year saw seniors graduating with no jobs. There were not enough jobs in biology despite its excitement to give everybody a job so, it started down. In the last few years the number of degrees in biological sciences increased again. That's because biotechnology is becoming industrialized now and there are beginning to be more industrial jobs for people with backgrounds in biological sciences. I predict it will rise on up again as that job market expands. Degrees in chemistry and physics are both down. They both peaked in 1970 and have been going no where ever since. I have said this many times to the American Chemical Society, to the American Institute of Physics, and I've not gotten lynched. In fact, I have gotten a lot of support for it. This is no way to teach the introductory courses in chemistry and physics at both the high school and college level. What do I mean by no way? One is we don't teach about current application. I'll give you two examples.

In chemistry a huge example is plastics. They have revolutionized our world. They are the heart of the whole chemical industry. They are now a half a century old. They were commercialized in 1939 and yet, they have never crept into the curriculum on chemistry. Engineering? Yes. Not chemistry at either the high school or college level. There are not fifteen chemistry departments in the United States which do any significant teaching or research regarding this. That's weird.

In physics, the weird, weird, weird omission is electronics. Electronics are revolutionizing our world. Everybody is using electronics everyday. The typical introductory course in physics does not touch one single bit on electronics. They do not mention semiconductors, transistors, silicon chips, or integrated circuits. You could go all the way through science education in the best high schools in the country taking all the science courses they offer, not the technology courses but the sciences courses, and never hear anything about modern electronics. No wonder kids are not going anywhere.

I think the people who are doing a tremendous job of teaching electronics and making science much more interesting at the high school level are the technology teachers. That is why I would encourage a kid to take Principles in Technology instead of physics. Principles of Technology is a modern, useful, up to date, interesting, valuable course. High school physics, by and large today, and only 16% of high school students take it, is a trivial, outdated, boring, useless course. I have said that to physics teachers also.

Let me show you how this transfers to another area as. Look at what happened with mathematics. There was a very sharp rise in bachelor degrees during the last half of the 1950s up to 1970. Now I am not a mathematician and I could be wrong in this but, my impression is the computer business was beginning to take off through those years. Kids thought that mathematics, a degree in mathematics, was a way to computers. They finally learned that math departments, by and large, didn't want anything to do with computers. They did not want to handle numbers. They weren't applying computers. It was not a good move into computer science so *whoomp* down it came and simultaneously began growth of the new and still rather ill defined field of computer science. In other words, young people want to be prepared for the world that is out after they get out of school. The educational world often double crosses them and does not prepare them for that world. We have got to change that. One of my strongest beliefs is this idea of let's take the whole continuum of technical education and the relationship with technical education and the rest of society, business and so on, and let's help each student have and opportunity to pick out of that continuum what will serve that student well in the future.

Let's look at the order of growth of these fields. All fields with the bachelor degree rose 3.4 times what it had been. The fields that are lagging are chemistry, physics, and math. I think that is because the teachers of those subjects have gotten out of touch with the world outside of education. The fields that are increasing faster are biological sciences and engineering. It is not true today that kids are shunning the technical fields. They are shunning the ones that they don't see as being relevant to their lives in the future. They are going into those subjects that offer them some promise for the future. The biggest major in American colleges and universities today is business. Twenty percent of all bachelor degrees today are presented in business. The interesting thing is that back in the 60s the biggest deal was education and 20% of all the students were going into education. That's now down to 8%. And that, I would argue, is logical. I don't think you can blame that on education. The job market dried up in education because of the demographics. Kids didn't see jobs out there in education so they stopped going into it or reduced the number going into education. I think we have got to relate education at all levels to what students are going to encounter when they leave the educational world.

How did we ever come to the semantically ridiculous position of calling a certain narrow segment of education vocational education? I argue that all education is vocational education. The only people for whom education in not vocational education are a few sons and daughters of very wealthy families who don't happen to have to work the rest of their lives. Everybody else has got to deal with whatever education they need to go out and get a job. I don't regard that as crass money grubbing. I regard that as normal acceptance of human living. You have to earn your living. Let's stop the talk regarding vocational education as a special little segment over here. Let's prepare people at all levels to go out into the world in which they can make a contribution and, in return for making a contribution, earn a reasonable living. To do that, I don't care at what level, whether it be at the Ph.D. level or whether it be at the high school drop out level, what we need to do in preparing the workforce of the future is to teach people to learn. They are going to have to keep on learning all of their lives. One thing that you can be sure of is that whatever you teach them, if you can teach them all the human knowledge to date, that would be insufficient before the end of their career.

You know there is going to be a lot of new knowledge. So they have to keep learning all of their lives. That is what industry is beginning to realize even at the plants lower jobs. They want people who can continue learning. Secondly, they want people that can think. It is no longer enough to go out and say, "Ok, I'm going to turn this knob, pull this down, take this off, then it's done." Industry is looking for people who can think. Big industry is looking for people who can create. People who can look at a situation and invent a new way to deal with that. We are looking for people who can solve. People who can see a problem and say, "Oh, I think that can be solved this way." We are looking for people who can cooperate. The American obsession for independence can go too far. Cooperation is an important skill and a requirement in modern industry. We need to turn out people at every level who can learn, think, create, solve, and cooperate.

Thank you very much and I look forward to the deliberations that will go on here as we continue with this very interesting and very important study.

THE CHANGING WORKFORCE: IMPLICATIONS FOR SECONDARY SCHOOL PROGRAMS

Franzie L. Loepp

For almost a decade now we have been emphasizing the three Rs, to the point that we are in a rut. We just keep talking about those three Rs. What are those three Rs? They are reform, restructure, and revitalize.

Last night we had a report from the Secretary of Education. How are we doing? Apparently we are not improving much. We have had at least seven years since the *Nation At Risk* report came out to work on these three Rs. Like Allen McClelland said, we have been generating lots of reports that should be giving us guidance as to how we might reform, restructure and revitalize education.

In preparing for this session today, I had a set of transparencies that went through the information from those reports. I took them home last night and looked through them and said we've probably done that enough. Let me spend the time with you this morning talking about an effort that I have been involved with for a decade prior to the reporting times and causing some reform, restructuring, and revitalization. It hasn't been easy, and it isn't finished. I want to share with you some of the things that we have learned.

In the area of reform, nearly 10 years ago a group of educators in Illinois decided that maybe it would be OK to reform industrial arts and come into a new basic called technology education. That took a lot of risk on our part. We are finding out, we have certainly found out over the last decade, reform is not easy particularly in education. There was a really great guy on the U of I faculty that sat in one of our meetings and, he said, "This is exactly what we ought to do but, we'll never get it done, it's just too hard to reform education." But, we tried and we have made some progress.

We took courses in terms of restructuring and we changed from woodworking, drafting, and graphic arts to technology-based courses like communication technology, production technology, transportation technology, and energy utilization. The premise was, at that point, that all humans no matter which culture or which time in history have communicated. They have all been developing. They have moved from one place to another. It has been in the last century that technology has made the way humans do those things so much more sophisticated and, with a much higher quality of life, if you look at it from the 21st century point of view.

Of course, we use a lot of energy to do those things. You might recall at the turn of the last decade we were still remembering the energy crisis.We had a lot of long lines at filling stations and so there was a task force the governor put together that talked about what should be done about our energy problems in Illinois. The Task Force found out that 80% of our Illinois energy dollars went to five other states and it was causing our industry in this State to be less competitive. One of the recommendations was that we do something in education and so that's one reason the energy course got into the curriculum.

Over the last number of years, we have made an attempt at revitalization. There have been workshops. There have been graduate courses. All kinds of things have happened to help the teachers make the transition to reform industrial arts and come into more of a technology based curriculum. New materials have been generated to help in this process. Let me tell you, many problems have been encountered.

The teachers, in 1985, at our workshops could not even put disks into the computer let alone turn it one. Eighty percent of the teachers in 1985 had no computer literacy at all. There's a place to begin. We needed to have the kinds of experiences that would let teachers develop their computer literacy and ability to use the computer. Now, when they attend a workshop and you ask a question on the evaluation, "Do you use computers in your teaching?" "Do you use computers in your classroom?" Only about 30% will answer no. So, there has been a marked increase in the use of computers, the development of the ability to use computers by our technology teachers.

Another problem, teachers thought there were no resources. They thought the administrators wouldn't support the changes. They had not been getting resources into their traditional programs for years. They had been denied over and over again and, so, they had come to expect that resources were not available. We needed to somehow convince them that a deserving curriculum deserved resources and that we are, in fact, a wealthy state in the nation. If we can prove that something is going to be useful in preparing our students to live in the 21st century, the resources will come. In many instances we can point to that and say, "Yes, the resources did come." As soon as they had enough confidence to share with the administrators, the board of education,and other teachers the changes they wanted to make and how those changes would better prepare students, resources began to come. We can point to stories that are of huge magnitude in the order of a quarter of a million dollars or we can point to the $500 supplements, and $10,000 supplements in some of the smaller schools.

I want to divert just a minute. This resource situation is kind of interesting. After 1983 when we began to try to reform, restructure, and revitalize, reform often meant just adding more of the same to the curriculum. You know that reform, if you have a requirement of two science courses let's add a third. Restructuring often meant dropping out of the curriculum some of the less demanding courses to make sure that students only had a choice of the more vigorous courses. Revitalization meant put a few computers in the school. Many decided that if they could just add some computers they could revitalize the curriculum just like magic. A lot of students were playing computer games, maybe learning something, but probably not getting real curriculum revitalization.

Another problem that we found with teachers was that their conceptualization skills were lacking. They were used to teaching students to operate a machine to change the form of material and put it in to some useful product. They were not used to going from the hands-on to the learnings-on kind of situation. However, society is changing that whole mode of operation dramatically. Most workers now definitely need to have a minds-on orientation.

Conceptualization skills will help the learner understand where this information is going to help them in the future. It helps learners understand how this concept can be connected to other concepts. Our teachers did not have those skills. We need to come up with ways to help teachers develop those skills. Now that we have had at least five years of workshops to help teachers, I must report to you that to this day, we still have many problems in this regard. We know that teachers may change activities in the classroom, but they still are not sure why they are teaching what they are teaching. That's a bit of a problem. They still are very much machine oriented, task oriented in nature. Those are just fine but, they need to add to that activity the concept development and most of them are lacking in that regard.

We have a history to deal with. Many of the teachers we are working with had been teaching in the late 60s and early 70s when there were reforms in our discipline. A lot of federal dollars went into the development of master curriculum such as the Industrial Arts Curriculum Project, the American Industries Project, and those kinds of materials were extremely well done and have, in fact, had an impact on what we are doing today. Teachers had experience and attempted reform, but it was aborted. They tried it for awhile and they found that most teachers reverted back to the teaching of woodwork, drafting, metalwork, and those kinds of things. They just viewed the next reform as being something that would come and go. There is really no use in getting too far into this thing because it takes a lot of work and takes a lot of time and it's going to take their resources but, let's take the easy way out and allow the reform to pass.

Teachers complained of fewer and less able students. Now that is a typical statement that most teachers are still using today to resist reform. "We just don't have strong enough students to teach technology." We have teachers that proved that an inaccurate assumption. Rick Satchwell at Cunningham Children's Home in Urbana teaches students that are less able and they enjoy technology. They enjoy learning about technology. These things help them extend their potential. Teachers can't use that argument to resist reform any longer.

Another problem in the early days was that commercial materials to help teachers were scarce, virtually nonexistent. There were a lot of woodworking textbooks but, not many communication/technology textbooks. There were a lot of activity ideas in periodicals available through the commercial markets for woodworking and metalworking, but not in the technology area. So, those were scarce and they caused us a lot of problems.

As you can see, new competencies needed to be developed. Most of those centered around the computer. It was awfully enlightening to many of our teachers when they found out that the most important tool in our society is not a table saw, but rather, a computer. And it is a very, very versatile tool. The computer can do so many things and it is doing so many things in our everyday life. So we need to help teachers understand how to select the hardware, the software, and then use the various kinds of software. That takes time. So, along with this skill, is the ability to read documentation put together by someone who really understood the software but, didn't know how to write it down so others could understand. We had teachers spending hour after hour after hour learning how to use documentation and learning the software. We needed to teach teachers how to use software that was generated for one purpose but, could also be used for another purpose. Let me give an example. There is a simple piece of software that can easily work at the junior high school called *The Factory*. The students get a chance to choose various machine tools to build certain parts. Well if you don't have a computer numerical control machine, you can also get across the concept that as this computer is being used to set up a factory to generate a part, if you have it print out your result, the printer can be used as a numerical control machine. It doesn't have to be a milling machine or a lathe or that sort of thing but, you can get the concept across. Some teachers began to capitalize on software that was designed for one purpose, but used for another purpose.

Interfacing skills are still a big problem. Invariably the computer manufacturers don't understand that you purchase components that they didn't design and you want this CPU to interface with this output device and that sort of thing. It has been a lot of trouble teaching teachers how to use various input devices and connect those with a computer and then connect that with various output devices. Teachers have also learned that they can add cards to the microcomputer to have the computer do a lot of neat things. I'll give you an example that intrigues me. There are teachers that will have a simple low end computer, maybe an Apple IIe, control eight 110 outlets. Then they can use their traditional machines in their laboratory and build machine centers that can be controlled by a computer. It gives them a lot of flexibility. We are not only interfacing the computers with computer-oriented equipment but, with traditional equipment as well. That makes the opportunities for problem solving and learning on the part of the students extend immensely.

Teachers need to have some upgrading in instructional technology in terms of the use of video. Many of them were not using video, let alone interactive video. They didn't know how to use a modem to tie into data bases. They didn't know a lot of the ways that you can enhance the environment using technology. Here we are trying to have teachers teach about technology but, they didn't even know how to use technology to help their instruction. In some cases we have to set up situations so we can show teachers that this piece of technology can make learning more efficient, more effective, and invariably, the teacher, once they understand how computers can be used or how instructional technology can be used, is usually very willing to give it a try.

We need to teach teachers how to identify, access, and utilize quality information. We are in an information society but, which information are you going to use? We don't have time to read it all, look at it all, view it all. We have lots and lots of videotapes. Let's take NASA for example. You can just spend hours and hours and hours viewing tapes from NASA. Many of them are years old. We need to teach students what sources are apt to be the better sources for today. We need to teach them which data bases to use. In the mid-80s there were data bases were flourishing. Everything was put into a data base and most of what was in there didn't deserve anyone's attention. You have to help teachers understand that just because it's information doesn't mean that it's good information. It may just take too much time. There are many new periodicals that are available now. Alan McClelland mentioned *Ties* magazine. It's a beautiful little magazine. It takes time, education, industry, and government together to teach technology to children, to teach technology to those students in our classrooms. Many, many other periodicals are being relied upon in addition, or instead of the older, less applicable periodicals. There is also a strong need to build networks among fellow teachers. Teachers get discouraged during reforms. It takes a lot of energy to reform and they need some kind of support system. Fellow teachers often provide the little bit of encouragement they need. Sometimes that fellow teacher is even in their same building. It could be a science teacher or a physics teacher that gets turned on by the kinds of things that the students are learning in the technology laboratory. Those kinds of support systems are extremely important.

I have already talked about concept development. We need, I think, to continue to develop within our educators the ability to identify concepts that are important and transmit those to students. There are a whole series of teaching strategies that our teachers weren't acquainted with and did not use that are now becoming very prominent in the technology laboratories. Strategies such as research and experimentation.

We are being impacted greatly in our discipline by a movement that's going on in England where the national curriculum now suggests that 10 percent of all students' time from age five to age 16 be devoted to a study of technology. Five years old to 16 years old, and their interpretation of how to study technology is to design and solve problems. Some of the things that are going on there are extremely exciting. Let me just give an example.

A sixteen year old girl reading an autobiography written by a blind person noted that that person had trouble identifying what was in a can of food once the food was at home and on the shelf. Now, how are we going to help people who cannot see determine what is in a can without opening the can? This young lady went to the grocery store and looked at cans and tried to find out what might be a distinguishing characteristic. Finally, she decided that every can had a bar code. She had to spend some time researching to find out what bar codes are, how they are read, etc. She found that a light pen doesn't need to be very expensive. She then needed to learn how to design a technique for the light pen to read a bar code, transmit that information to a computer, and then to a voice synthesizer. Within 80 hours of laboratory work she was able to successfully design a device that would read the bar code on a can of food with a voice telling the person what was in the can. A terrific problem was solved. That student had not had any electronics prior to this problem but, that student now knows how to find information on her own and to look for ways to improve a situation. That is a skill that will help her throughout life.

Alan McClelland mentioned that in industry most people are working together. In technology education we are advocating many, many group activities. Some teachers have done this before and some have had problems running group activities. The problem is that when they try to run group activities without some prior training sometimes chaos develops. They don't like working with chaos. They like to have everything very well organized. Another problem that they run into is how to evaluate students that are working in groups. Some students will do more work than other students and that is a problem they like to have answered before they even begin working with groups.

Group activities are great for teaching problem solving. Using students to help other students. Using advanced students to give directions to other students. One of the problems that some of our teachers are running into is they very much enjoy helping students. They get a lot of satisfaction out of helping students but, that may be the very behavior they should not engage in at this time, particularly in a problem solving or peer coaching situation. Once the teacher acknowledges that that's a good solution the students quits looking for other solutions immediately. We can give them some encouragement, but not too much in the way of praise until the solution has been tested and tried and it works. Some teachers have no experience in delaying their praise that long.

We found our teachers involved with program improvement. This isn't easy. You don't improve programs quickly. If they understand the need for technology education, and they want to make a change, we very strongly advocate that they make that change in increments. Produce a three year or a five year plan. Phase in one course after another course. Believe it or not, our teachers in this nation do not have very much time for planning. I had the good fortune of teaching in Japan for three years and the teachers that I worked with only taught two classes a day.

maybe three. I can't generalize that through the whole nation, but that's a pretty homogeneous group of people there and I would predict that all high school teachers in that country only teach two or three periods a day. Our teachers are extremely busy; they are overloaded. They have laboratories to maintain, they have new information to gather, and making a change is difficult even though support systems are available.

Facility planning is a problem. What are you going to do with that row of 12 machine lathes that was purchased in 1950? They are still in good shape but, what are you going to do with the space that they take up? How are you going to work some computer control equipment into that space? How, in fact, are you going to interface microprocessors and programmable controllers with one of those lathes? Facility planning is a real interesting problem that the teachers get to solve and, often ask students to help them solve. There is a public relations problem that they had to learn to deal with. They had been shop teachers for years and they are proud of being shop teachers but, suddenly, the designation of "shop" was not quite as comfortable to them. They need to get the message out that they are teaching about technology and technology happens in laboratories. Many communities are very appreciative of the woodworking projects that students brought home year after year. They do not see changing to a technology base which doesn't always result in an artifact as better. It takes a lot of energy to communicate to parents, to younger students, to administrators, and to fellow teachers in the community that reform needs to take place and, in fact, benefit the students. Teachers need to gage themselves appropriately. We had an International Technology Education Association meeting in Indianapolis a few weeks ago and I was thrilled at the number of Illinois teachers that were in attendance. That hasn't been the case for a long time. Only a handful will come to that professional organization for a meeting but, presently they see the need for connecting with a professional organization in order to improve themselves. We have had state wide workshops. We have had graduate classes. There has been an enormous amount of just plain hard self study, work it out on your own, develop new ideas, find new information, and improve your own skills.

Now I also have some suggestions on preservice. Rather than present a long list, I want to just mention a few preservice ideas that we are needing to work into our curriculum at Illinois State. One is that we have to have a much stronger background in mathematics, chemistry and physics, particularly for technology education. We need to have a better background if we are going to develop these concepts. If we are going to be able to communicate and integrate curriculum with the science departments, we need to have a sound background of the principles of mathematics and science. In fact, we are now advocating dual certification. Half of our graduates this year will be certified in either mathematics or physics as well as technology education. Let me tell you, the administrators' eyes brighten when they interview a student that says, "I can also teach mathematics" or "I can also teach in science." It almost gives immediate legitimacy to technology education. It isn't easy, at least at this time on our campus, to get dual certification. It means either going a summer extra or adding a semester or just plain extending your time on campus. Some students have found that to be a really a good way to go.

If you look at the demographics of Illinois as predicted in the future, we must expect that our preservice teachers have time with students that are at risk, students with special needs, and with people from different cultures. Two weeks ago I was in a school in a collar county in the Chicago area. Over the last three years the percentage of Hispanic students had risen from 8 percent to 33 percent. Some of them do not have good English skills. Those students bring a rich culture to that setting and many of our teachers don't know how to capitalize on it. They don't understand some of the ways that they can bring out the strengths of that culture and deal with the students that come from that culture.

Many of those reports that I read to prepare for this advocate the study of foreign language. I took foreign language. I didn't learn to speak it very well and I have forgotten almost everything that I learned in that class in terms of vocabulary. I did learn some culture and I did learn some things that I believe even help me to this day. I do know that we are becoming a global society with industry being interconnected with industries from other places and other cultures but, it will be a distinct advantage to teachers if they understand what is going on.

I find myself being asked to give support to persons in industry that are becoming linked with other cultures. My experience in Japan has proven to be extremely valuable because we are forming joint ventures even in our own community and I see the value of having lived in another culture. I would even advocate that all of our preservice teachers have that experience. I'm not sure how feasible that might be but, to live in another culture for a semester would be extremely valuable. We have on our campus that option available to all of our undergraduates. About 5 percent are availing themselves of that option. So, it would be possible to have all of our teachers spend at least one semester in another culture and get credit toward their baccalaureate. And then, of course, we need a very broad technical preparation. Fortunately, some of the classes at a university provide a broad technical preparation. However, most of them provide a very in depth technical preparation in a very small area of expertise and this becomes a challenge for all of us in technology education. How can we provide a broad based background to teachers who would like to teach technology?

The best preparation for changing the work world is one that stresses flexibility and adaptability. We must build a sound basic education which includes literacy, communication skills, logic and reasoning, mathematics, science, and broad technological applications to enable the students to learn new job specific skills throughout their working life. I believe that should serve as a guideline for the future in technology education. I'm optimistic about that. It has been a hard ten years within our own state but, there are indicators that, I believe, are going to help us keep the momentum going. Some of those indicators are the National Goals for Education. We may have peace dividends. NSF may have more money in the future. They are becoming flexible enough to let people like myself at least be considered for some of those funds. We have a lot of integration activities going on and they are very useful. There's integration going on among the mathematics community. They are even coming out with extremely well designed, restructured curriculum that offer the opportunity for applications. NSTM (National Society for Teachers of Mathematics), the AAAS (American Association for the Advancement of Science), and Project 2061 are causing mathematics, science and technology to be integrated. Those are wonderful movements that I think will help with reform. We also have vocational education becoming more general. Finally, we are understanding how important it is to get a more general orientation to our students so that they are more flexible when they get to the work place. We have many teachers that are going to retire. That's positive. It means we are going to have new teachers filling that void and they are going to be more anxious to cause some change. We have the use of technology in education that will help us. I'm optimistic. I think it has to come about. So, let's meet the challenge. Let's reform, let's restructure, and let's revitalize.

THE CHANGING WORKFORCE: IMPLICATIONS FOR COMMUNITY COLLEGE PROGRAMS

Daniel M. Hull

Someone asked the types of things CORD does. I think most of you probably do know CORD, but we are not as well known as the National Science Foundation or some of the institutions here in the state. Let me just say that we are a nonprofit organization located in Waco, Texas. We really do about four things. One is to develop curriculum and instructional material for technical education in emerging technologies. We have been doing that for the last 18 or so years. I have been with CORD about 17 years now. I started to work with CORD in the development of a laser-electro optic curriculum. We have developed numerous curricula in emerging technology since that time.

We have also been involved in the last few years with the evolution of advanced technology centers (ATC's) in community and technical colleges. ATC's are a new, emerging organization within the two year schools that have a strong commitment to providing customized training and other technology transfer services to industry. Rock Valley College, which is in Illinois, is in that consortium. There are fifty members at this time. There staff are really working hard to try to identify what industry's needs are, as well as trying to sort out and redefine the appropriate partnership between public institutions and industry. I think that partnership needs to be renegotiated. It needs to change and it will take new attitudes to change.

The third thing that we are involved with is the applied academics curriculum. The *Applied Academics* curriculum that we have been privileged to be involved in is for high school students and adults. I want to talk a good bit about that because I think their role, particularly in two year schools and maybe other places in retraining and re-educating the adult workforce is maybe as challenging as the high school role is right now. We have been extremely pleased to be able to work on courses like *Principles of Technology* and others I'll talk about in a minute but, CORD did not develop those and CORD is not alone responsible. CORD did a lot of the staff work. We have a person on our staff named Dr. Leno Pedrotti that generated many of the ideas and much of the sweat came out of his work. But, these were consortium funded and consortium developed projects with people like Sandy Mercer and others on that staff.

Principles of Technology is a curriculum in applied physics involving a partnership with 48 states and two Canadian provinces. I should tell you that usually Illinois is the first state that commits to these consortia. But, they don't just pay their money, they utilize the materials very well.

I won't name them all but there are five or six or seven states in the country that are really professionally oriented toward curriculum. I would say that they are taking the leadership in curriculum work. I think Illinois is one of those states. It is a privilege to work with the staff and the people in your schools.

The other thing we do is provide assistance to schools in technical education initiatives like the Tech Prep and the 2+2 articulation and retraining the adult workforce.

I want to talk first about advanced technologies that are part of the topic of where we are and what we see. We've developed about sixteen or eighteen different curricula in emerging technologies in the last fifteen or sixteen years. There are certain characteristics of most of these that you can put together in specific ways. We started trying to look at all of these. Throughout a period in the seventies we looked at each curriculum as a completely separate specialization. When we developed a laser curriculum we included a large number of laser courses. We thought that laser technicians ought to have a narrow specialization without math breadth. We began to change our idea around 1978 to 1980 and said, "There is an awful lot of commonality in the various curricula." That happened in '80 and '82 around the time that the concern for high tech was developing.

This began the second technology hype that I've experienced in my professional career. I guess the first one occurred around 1960. The second one started around '78 or '80 and I don't think we are through yet. We don't call it high tech because we got tired of the word. We call it advanced tech or modern tech, or whatever. Whatever we want to call it, there are certain characteristics that aseem to prevail.

We are operating at technical frontiers. In curriculum we want to anticipate what is needed in the future. What we are designing now will be used to prepare people who will be going to work in 1993, 94, and 95. So, we have to prepare for the future and flexibility in the curriculum is certainly important for that.

The second thing is that advanced technology overlaps several of the engineering areas. If you look inside a photocopy machine or a robot or most any modern equipment you find it is not just electronic or just mechanical or just hydraulic or just pneumatic. It involves combinations of these disciplines. Our curricula needs to prepare people who have a systems orientation. They need to be able to see a variety of technical areas which we used to limit to one specialization. We've got to build that into our curriculum. We certainly need to involve computers, at least in three ways for technicians. One is an information device to retrieve, to store, to massage, and to display information. Another one is to make the machine smart. Get a photocopy machine or a robot or whatever and to allow them to automate more. The third way is in design, computer aided graphic design and integration in manufacturing.

We know that advanced technologies are changing rapidly. We need to be able to judge our curriculum in such a way that we can identify those areas where the changes are occurring and keep those up to date. Also, we must prepare people who can't keep up to date.

Finally, there is much stronger need for knowledge of why as well as how things happen. I'll give you an example of a program we are working on. I'm an electrical engineer so everything I do looks like a wiring diagram. The last four months we've been involved, and we will continue for another sixteen or eighteen months, with the design of a new curriculum. We require a new type of employee to send out to the manufacturing industry. Most of you have heard about a year and a half to two years ago that Sematech was formed. They were formed down in Austin, Texas. They are a consortium of fourteen major corporation that are involved in the manufacturing of semiconductor devices. Their concern is that the new equipment used in photo lithography and other techniques in their manufacturing process be developed by suppliers in this country rather than in foreign countries. So, they are continuing to work on new processes not as a central research and development service for all these companies but, to try and help the suppliers maintain their competitive position so that they are not dependent on foreign suppliers for their production equipment. Sematech is very concerned about that. They are also concerned about the fact that they are going to need a different type of operator in their production facilities. So, we were funded by the U.S. Department of Education and are working through Sematech to design a curriculum for semiconductor manufacturing techniques. We have an advisory committee with representatives from these fourteen companies. We are asking them the typical things like, what do you want these people to know and do when they go work, not today, but 1993 and 1994? Then, we will design a curriculum. This curriculum will be tested down at Texas State Technical Institute in Waco, Texas. Then, they will be introduced around the country where they will be replicated.

Here are some of the things we've found. The product, a chip, keeps getting smaller and smaller. Right now it's down to the size where the distance is approximately one third of a wave length. That's very small. It is small enough that really tiny particles of dust and impurities can fall in between conductors and short out the circuit. They are trying to build these circuits keeping the environment in the production area very clean.

They take sand to build a chip. They purify it to a very pure silicon. They form a cylinder of silicone which is usually 5 to 8 inches in diameter. They take that pool and slice it very thin, down to a millimeter in thickness. After you slice it you have a 5 1/2 to 8 inch disc that is very thin. It looks like a compact disc. Then, they start building up layers on that. They make thousands of these chips on one disc. Once they get them all done they test them. They saw them up and put each one of those thousand in here and attach leads to it.

They take that silicon wafer and put a layer of some different material on top of it. Whether they do it in a vacuum chamber or in some other way, a chemical way, they put a layer of material on there. Then, they put a pattern on top of it. They make a mask out of it. They go through a photographic technique and some curing techniques with ovens and such. Then they can pour an etching solution that will eat away part of that material. They will alter the characteristics of that layer. They may build up 15, 18, 20, 25, layers. There are usually 90 to 110 steps in this process. Each layer represents another element of that circuit. If you have 5% loss in one of those steps you may only achieve a 25% yield. If you are up to a 99% quality or 99 out of 100 good ones, you will get up to about 65% yield. You've got to be around 99.9% to get where they want to be. Which means they can't make very many mistakes and there can't be very many impurities in there.

I'm telling you this to explain what they have now. They have four types of workers in a semiconductor manufacturing plant. They have an operator who operates either a piece of lithography equipment or some etching solutions; someone else who maintains that equipment if it breaks; someone called a process technician who is trying to alter the process by adding one more second to the etching time or raising the temperature a little bit to see if that improves the yield, a quality control technician. In the next two to three years they want to have one person to replace these four. They would like to cut down their staff inside these processing plants to one-third of the present level. The reason is not the cost. The reason is contamination. People put out lots of contaminated particles. These people have got to eliminate 2/3 of the people in that plant to get up to the high yields they need to have. They have got to automate more processes. It is not good enough to have 43 seconds in the etching solution if you have got to have 43.6 seconds. Automated equipment will make that more accurate. So, they are looking at a way to eliminate or combine these jobs into one job. That just says the jobs are getting more complex. We've seen that in many technologies. This one is probably as intense as anything I have seen in a long time.

We've looked at this occupation and 12 to 14 others. There are really about four things that advanced technology occupations require. One is a systems orientation. Another is a combination of skill, interdisciplinary skills. This means the curriculum cannot be a narrow specialization. We've got to have breadth. We've got to give up some depth for breadth at the institutional level. We must reach a certain level of depth or we have a "jack of all trades and a master of none." The way to get to that increased depth is not to limit the breadth but, to raise the levels of math and science for people entering these programs. The strong technical base requires more math and science before entrance. The last one, which is extremely important, is interpersonal communication skills. Which, in some cases, may be taught in separate courses in the curriculum but, in other ways need to be reinforced with team activities.

If we looked at a list of some of the high tech programs from 1985 we'd observe the following: computers, telecommunications, non-instructive testing, computer aided graphic and manufacturing, instrumentation control, robotics, lasers, energy management, and biomedical electronics. That was a fair number. We could have added other things like nuclear technician and so forth but, in 1985 they weren't too popular. They are coming back again.

We tried to design a curriculum that would serve a variety of specializations and yet have the flexibilities we've talked about. We went back and redefined what we call a technician. A technician is a person that builds, modifies, installs, maintains, repairs, and calibrates the type of equipment and processes in these types of organizations: manufacturing plants, energy plants, processing plants modern buildings, hospitals, clinics, and communication systems.

If we pulled a generic list of 8 to 12 different occupations in the technical field, nine items continue to emerge each time. Now you may only find seven or eight of these in any one field but, you will continue to see them over and over again. The nine common items include using basic principles, concepts, the laws of physics and technology (practical applications), math, problem solving tools, analyzing, troubleshooting, repairing systems that are composed of different disciplines, different engineering disciplines, using materials, processes and apparatus common to technology, and applying the technology of one field with an understanding of applications in that field. A good example of that is in lasers. It is not good enough for a person to be a laser electro-optic technician. They need to know how to integrate that into a machine for manufacturing or into a diagnostic medical treatment tool. They have got to expand beyond just that one technology.

What's happening I think is a result of the kinds of things I've talked about. I think we are restructuring, rethinking the structure of vocational/technical education. We are in some sort of a transition period. I said before 1985 and perhaps after 1992, you might argue with these dates, but I think before 1985 vocational education did what we were asked to do and did it well. We taught tools and techniques. We didn't concern ourselves as much with foundations. The need was not as great at that time. VocEd meant tools and techniques. Competency-based education meant teaching the task. It shouldn't mean just teaching the task any more. You have got to go far beyond that. It's what are the underlying skills and abilities in science and math and other areas.

The craft workers were the skilled tool holders. The tools and techniques didn't change very quickly. We could afford to keep people in a mode of tools and techniques longer. When those did change workers couldn't adapt to the changes that were required.

I remember having a radar systems operator that worked for me when I was at NASA. This person operated a military radar as a reference radar and he could do anything with it. He could repair it, calibrate it and get it on line in forty-five minutes. One day we changed radar. We went from that standard radar to a new one. This person had to go back to school. He could not transfer any principles or tools from one radar to the new radar. That was the way he was trained. I am not arguing with that. It was the way the army had to do it for people who are only there for two or three years. That's not the way, as educational institutions, we should do it, particularly in today's world. The foundation was lacking for advanced training. So, we really didn't have a foundation for retraining. We had to go back.

In many modern manufacturing organizations we're having to do "bandaid" approaches to retraining. If you take an electrician in the manufacturing area and you try to teach him about programmable logic controllers you could get some company's Model 23 Programmable Logic Controller and you could teach that the blue leads hook up here and the red leads here and the black leads over here. You could have a troubleshooting chart that says if this symptom occurs do this and if this symptom occurs do that. That may be all you can do in a "quick fix" for an electrician; but, the new automated manufacturing technicians need to know the principles involved in programmable logic controllers so that when the new model comes out they can transfer the knowledge they have to the new model.

That is where we were. Where I think we are heading is blending vocational technical education with academics. We require science and math in addition to tools and techniques, not in place of tools and techniques. I think we have to do both as we begin to lay a foundation in place. Just as the speaker this morning was talking about the importance of certain skills learned in high school, I think we have got to continue to look at that. If we have a foundation in place, retraining means building upon that foundation. In that way, we can retrain people easier and we have more flexibility.

To complicate this one step further, in 1985 we went to a core curriculum. I think core curricula in technical fields in post secondary institutions is extremely important. We at CORD have been on a mission for the last eight or nine years. It's limited by the resistance of faculty to adopt it. If I am a faculty member and I have had eighteen courses in lasers and optics and, all of a sudden, I've got to get that down to seven or eight courses in laser optics in order to achieve breadth, I'm not going to like that very well. First of all I'm losing some turf. Second of all I'm not sure if I'm going to fit into this in the future. There has got to be a transition that is made in the mind set before we can go into a core curriculum.

We show a common core with, generally, an electro-mechanical base core. It had a basic skills component of math which went up as far as pre calculus, science, which we said at that point was physics and it needed to be good practical physics, communication skills, computer literacy, using personal computers, interpersonal skills, and some economics. We said that there is a technical core which is the electro-mechanical core that builds on this math and science foundation in the areas of electricity, electronics, mechanics, electrical mechanics, materials, fluids, graphics, controls and so forth. Layered on top of that you could build a number of different specializations. Utilizing that common core plus what turns out to be approximately twenty to twenty five percent specialization is sufficient to prepare a person to work in the laser electro-optic series, or instrumentation control area, automated manufacturing area, telecommunication, computers, andso forth. There are a number of models. They represent curriculum designs that we have gone through, people have used, and have been validated by employers. The basic core in telecommunications is math, science, communications, interpersonal and economic skills. If we switch from one specialization to another the core basically stays the same. The basic and the technical core stay the same while the specialty changes. When I had to trim from twelve courses in laser electro-optics to six to get breadth, I felt like I was cutting my heart out. I'm sure that is the kind of feeling a lot of faculty will have when they do it. I think the whole concept of core curriculum is extremely important but requires a significant change in attitude.

Let me tell you what we see happening in the 90's. We still have computers, telecommunication, computer aided design, integrated manufacturing, automated manufacturing,and intelligent buildings. This is an interesting one. These are buildings with a lot of zoned air conditioning with computer controls, internal communication systems utilizing fiber optics and a lot of other things that need to be maintained by a different type of a person than we had. Now we see emerging fields like biotechnology, hazardous materials management, material technology and semiconductor manufacturing. All these have at least one component of chemistry in them. I think there is a trend. In addition to the breadth that existed in the core curriculum, we are going to have to look at expanding that core. This complicates it further.

Someone mentioned earlier today that it is always easier to add one more course to a curriculum than it is to take one out. We may have to do it. Here is what we are starting to see emerge as a different curriculum structure. In addition to physics we have chemistry, maybe biology. Math, communication, computers and interpersonal skill, and maybe something else, we are still sorting that out right now. We certainly see vacuum systems appearing in many of the areas. This type of curriculum is what is going to be needed to serve the technologies which are more prevalent right now.

One of the things that we learned working with this core curriculum is we think it's the right one. We've shown this to five, six, seven-hundred employers and small groups and say, "Is this the right way to prepare people?" And they say, "Yes." Most of them say the core is more important than the specialization. The specialization is the part which changes a good bit. Specialization though is important. That is what keeps the student interested, keeps them in school. If they choose to be a laser technician they had better find some laser courses in the curriculum. It also helps them get that first job and it probably helps more in that first job than employers are willing to admit. The core is what prepares them for a career, what gives them the breadth and the flexibility to stay employed longer.

The problem with this type of curriculum and the models that I have shown you is that you cannot do it in two years with the kind of students we are getting today. The students are poor in their math skills. Most of them have not had a lab science. Their reading levels are a lot lower than we would like them to be. They need a lot more basic work in writing technical communications. So, we are very interested in and, it is a good time to be very active in, ways that will allow us to better prepare students in our community and technical colleges.

Some students are coming back to school after being at work. They left high school to work for eight or ten years and decided they can't raise a family on their income. They are in just as bad of shape and sometimes worse shape in their math, science, and communication skills as the ones coming right out of high school. Others didn't plan for these types of careers. They went through college in a liberal arts area and decided they wanted to change careers or enter a career and, so, they come back. The foundation has to be rebuilt. So, we're trying to at least lay a path.

These are brochures that describe the *Principles of Technology* and *Applied Math* curriculum. Basically, they are achievable by non-baccalaureate bound students. We are finding that these students are really capable of a lot more than they have been doing. Maybe it's interest. A lot of it is confidence. The other part of it is that many of these people learn by application much better than they learn in a theoretical way. A hands-on learning approach may be one of the most important elements that vocational education has brought to education in the last ten to fifteen years. Applied physics and applied math do not mean "watered down physics" or "watered down math." It means that we are teaching it in a different way.

I guess one of the strong messages I want to say is that we have got to go back and take a look at curriculum. We have got to develop a philosophy that says build a foundation and then in bold letters build on a foundation. We are seeing *Principles of Technology* and *Applied Math* go into programs and schools around the country. Maybe for an electronics major. They've got more physics, they've got more math but they are still teaching electronics the same way they did when they didn't have the physics and math. So, that curriculum has to change. I can't imagine a good reason to teach a term of DC, a term of AC electronics and still define that as 80% of the curriculum. That is the way it was taught in 1955 when I went to school and that's the way they may have learned it. They're still teaching it that way and, you can really cut out some things. You can cut out a lot of network analysis and other things. You can build on skills that they learned in their physics. We've got to look at the more integrated curriculum. Integrated means to me that each course has some tie or may have some tie to another course.

There's more that can happen in applied academics. I think these challenges are going to be out there in secondary and post secondary. There is more that can happen in applied academics than just offering alternate courses for the middle 50% of high school students. I think, in some cases, they're being used to strengthen existing VocEd courses by infusion. That's tough. Particularly with *Principles of Technology*. It is easier with the math model but, it can happen. I think the foundation for the Tech Prep curriculum is good. We're finding that these types of courses work very well.

Let me show you some things about foundation courses for retraining adults and also remediating entering post secondary high school students. If they come in without the math, science and communication skills that they need, they're going to have to be remediated. It may be that courses like *Principles of Technology* and *Applied Math* are more interesting and more achievable and more efficient than remediation of the courses they've had in the past.

The challenge for technical and community colleges is to put in the advanced applied curriculum talked about earlier. Whether it's the electro-mechanical curriculum or whether it's a chemistry curriculum will depend on the field. Put in the curriculum and make sure the students in that curriculum are ready for it. Getting everybody up to the same level is always a challenge in education. One way is to utilize the 2+2 or Tech Prep articulated programs. Also, for people who are coming to the community colleges, technical colleges and saying "I want to change careers, what can you do for me?" You've got to remediate them. In some way all these things have to happen and we think there are ways to do that.

Let me show you what we think may be an ideal or a worthwhile model to consider in Tech Prep right now. Let's just take one of the electronics areas. Electronics really ought to be looked at to see the digital computer electronics, or telecommunications or instrumentations control. These are really different specialties within there. Let's just look at this one for a minute. To achieve a Tech Prep program for advanced skills, you've got to look at starting in the 9th grade going through two years post secondary. You've got to look at what is the string of math required? What's the string of English? Communication skills? What are the sequence of science skills? Of humanities, of other types of courses that are needed? What are the technical core courses? Where do they fall in? Where's the technical speciality? I'm sure this could be modified for the State of Illinois depending on what the guidelines are for graduation. What we're trying to show is that you start with applied math or something in the ninth grade . In the 10th grade use the math to proceed the first science course. That's building a foundation, and then building on the foundation. That's a different electronics curriculum than was taught before.

The second element I believe is that any good Tech Prep curriculum needs to have an exit point at the end high school with employable skills. One of the reasons is that over 80% of the students that are in technical programs in community colleges around the country are part time students. This means they've got to be working sooner. Everybody may not be able to leave immediately after high school and go full time. They may have to get a job and continue to work. They have to have employable skills. Some people would argue that there may not be enough specialization but I think there is. We've done some work that would show that.

Let me talk a minute about a program that we've done for retraining adults. We were asked back in 1986 or '87 by the Tennessee Valley Authority, to help in a retraining program for workers who were going to be laid off from a copper mine in Copperhill, Tennessee. Three miles from South Carolina, two miles from Georgia and Tennessee. These people were all from three different states and the Department of Labor could not figure out who was responsible for them. They gave the problem to the Tennessee Valley Authority. They came to us and said, "Could you design a program that instead of just teaching meat cutting, or truck driving, or a typical retraining program, one that builds a foundation for technical employment and build it around *Principles of Technology*?" So we did. This is essentially what was set up.

We've included math, communication skills, graphics and computers. Going on into the science, *Principles of Technology*, mechanical devices and so forth build some specialization. We did a little bit of work on it there and found out that it worked well. We really didn't have *Applied Math* at the time.

A year and a half ago we applied for and received a grant from the U.S. Department of Education to operate a model demonstration center for retraining displaced workers. This is being done jointly by the joint vocational school and community college in Oleria, Ohio. The students are actually going to Lorain County Community College. These are people who are unemployed. Most have been unemployed long enough to loose their unemployment insurance. They're at school 8 hours a day. They are in class 6 hours a day. We built the study time, homework time into the day for these adults. They're there 18 weeks. Six contact hours for 18 weeks is about a 540 hour program. They're taking *Applied Math*, personal computers, applied communications, graphics, mechanical devices, *Principles of Technology*, quality control, some electricity and electronics, and then some specialization area . We showed this to 10 employers in that area and said,"Will these people be employable?" They said, "You bet they would." And they are. We're in the fourth class. They have taken 26 people in each class. On the average they have lost 2 people per class. They've lost less than 10% as they go through. The people who went through this program are employed right now. They're not being employed as associate degree technicians at $10 an hour, they're being employed as technical workers at $6 and $8 an hour. It's working well for them. We're into the fourth class that should finish up this month. That program has been replicated in about six other places and I think it's going to get more replications as it goes along. It's really Tech Prep for adults. Some of the people that go through this program are going on into the community college. They would like to complete an associate degree in telecommunication, or computers, or something else.

Let me speak very briefly about a couple of other things. Some of the things relating to who are the students of the future. According to the U.S. Census Bureau, we're going to hit the lowest point in approximately 30 years of 18 to 20 year olds entering the workforce. There's going to be a shortage of workers. I think that the shortage of workers means we are going to need to use a lot more people in the workforce that we didn't want to use. Our students are going to be the students we've always served in VoTech plus the people in that forgotten half, the lower 50%. There will be displaced workers, adults that are going through career changes such as women and minorities, ex-offenders.

Someone asked earlier what all DuPont's training people did. I think I know what DuPont training people would like to do. They'd like to teach the people at DuPont the things that are specific to DuPont equipment and processing and they would like to get out of teaching the foundation courses of math and science. That means that schools should continue to rebuild or build the foundations. Rebuild if it's adults, and otherwise for high school students. That way employers can then concentrate more on high tech specialities. These advance technology centers forming around the country are trying to figure out how they're going to get $2 million dollars every three years for high tech equipment. I'm not sure they need that much specialized high-tech equipment. I think they have to have some and they could probably get some of that other ways than purchasing it. An awful lot of what they have to do is more generic technical training.

If we look at the increased requirements for faculty, more technical breadth, more systems integration, they've got to be able to teach human as well as technical skills. They have got to integrate those into the technical courses. They're going to have to look at building a foundation and building on a foundation. They're going to have to be proficient in the use of computers to create lessons, integrate labs, manage information, design curriculum, and control their classes. Finally, they're going to have to work together. I think that is the one that may need the most work. I can't tell you how to make it happen but, I think there is a reason for expending the effort.

THE CHANGING WORKFORCE: IMPLICATIONS FOR PRIVATE SECTOR TRAINING PROGRAMS

Joe Hill

First of all, as a senior training consultant at AT&T, my job is to formulate training programs for about 38,000 managers in the central part of the United States. That training deals with professional training as well as technical training.

Let's talk a little bit about AT&T prior to divestiture. First of all, prior to divestiture, which was in 1982, AT&T was the largest corporation in the world. We had in excess of 1.2 million employees throughout the world. We weren't really established in other countries so most of those employees were in the contiguous United States. When you looked at our workforce in those days, it was a very mature work force. The average number of years of service at that time was in excess of 25 years. Many times you would look at our book that we published on a monthly basis and it would list people with 51 years of service, 48 years of service and so on. You could look at four pages of people completing 40 years of service. So that meant when people went on board to work for Ma Bell, they would stay. The mentality was that Ma Bell took care of her children. No matter what you did, you knew you were there for life and, the benefits went on and on. Your job was to do your job, and when you retired you became what they called a telephone pioneer. This meant that you still had all the benefits that everyone else had who was still working for the corporation.

When you looked at our workforce they were very specialized. If your job was to work in the plants you knew your job inside and out. You were very specialized. You knew that job, but you didn't necessarily know anything else. That was okay.

In those days, AT&T was geared to service. They built their reputation on service, and even though they were a monopoly, they were thinking more in terms of delivering a service to the American marketplace.

When you look at AT&T prior to divestiture, again, we're talking about Ma Bell and her children, job security was the thing. Really and truly, I can't think of anything that you could do to lose your job once you went to work for Ma Bell. I have even heard stories of people who were caught thoroughly intoxicated on the poles, and the company would send somebody out to get them. You may have been sent to counseling, but there was never a thought that you could lose your job.

In 1982, to give in to the need for increased competition, somebody said it was time for Ma Bell to make her transition to divestiture. Judge Green gave us divestiture. Divestiture gave us increased competition. That was going to be the thing. To give all of our competitors an opportunity to have an equal footing in order to make money.

The next step was to improve our technology. Everybody was saying, "Look, we want computers in our homes. I want to have a telephone that can remember my aunt's telephone number in Peoria without having to pay an additional cost for that." AT&T went into a vein. What we call IM&M, Information Movement and Management. We wanted to teach all of our employees about a data base. They also need to know why we have these data bases. Ma Bell was dying and then, all of a sudden, the cry went through the corporation that nobody had job security. That's what divestiture gave us.

What did AT&T do to address itself in a competitive marketplace? First of all, AT&T recognized that if they were going to compete with the MCI's of the world, the Sprints of the world, and all of these little telephone companies where you could purchase a telephone for $5.99, they were going to have to reexamine their service options.

I was telling somebody at lunch that my parents still have the same telephone in their home as when I was in elementary school. This phone still operates in my parents home. It's battered but, if you pick it up, you get a dial tone. They can still call on it. That was the types of service that AT&T wanted to render. People began to say that wasn't important to them. They wanted to go out and pay $5.99 for a phone. So, AT&T decided to examine how they build telephones, how they build computers, and how they deliver a particular service.

There was a time you could call anyplace at anytime and information was free. Now when you call for information, there's a service charge. AT&T has to pay those operating companies that it once owned. Now AT&T pays access charges to those companies for them to hook into their network. Local companies have to pay AT&T charges, making your local bill a little higher. Because AT&T has to pay access charges into what is called the LEX (Local Exchange Corporation), you're long distance has to be a little bit higher.

The MCI's, Sprints and every other company in the world says that they are cheaper. So, now AT&T has to provide discounts in other areas. If AT&T discounts their long distance, that means the cost has to be offset someplace else, possibly telephone prices.

Let's talk a little bit about the ramifications. As AT&T was competing, they had to look at everyone in the marketplace. They had to look at all of their employees. They went through a process of evaluating each employee saying, "From now on you've got to make more than widgets."

How did they determine who was a viable employee? Well, maybe Mary Jones can make widgets, but John is a better employee. Not only can he make widgets, but he can evaluate people. He has more of a background in other areas. AT&T began to look at its employee base and said we're not really interested in what your degree is in. We know that you have a technical base, but now we're looking beyond just technology.

I was listening to all of the presentations concerning technology and what our people can do. There are some basic things that AT&T is looking for in an employee. Many times we have people that come in with a Ph.D. or an MBA. They come in to get a job at AT&T. The first thing they have to do is past the Personal Aptitude Test. I would say that maybe 65% of the people, regardless of their background, do not pass that test. Beyond that, they must pass what we call a Written Skills Test. We find that those persons who do pass the Personal Aptitude Test cannot get past the Written Skills Test. So we have a big problem. Being a communications company, we cannot hire people who cannot communicate. That's written as well as oral. So, we've got a little bit of a problem.

How do you build technology and cut costs at the same time? Well, one way to do that is to go through your employee base. You find that the average manager at AT&T, is hovering around $50,000-$60,000 range. You begin to think if I can get these people to retire, we can hire the graduates from the University of Illinois and some of the other universities, for $27,000. Now, you can swap the $60,000 salaries for a $27,000 salary. There are some ramifications to that.

AT&T finds itself caught in a two-fold process. In order for us to compete on a global basis, or even within the United States, we've got to cut costs as well as provide more advanced technology. So we're getting rid of people. The 1.1 or 1.2 million employees have diminished to about 252,000 employees. In order to cut costs and deliver service, we have constant attrition, a constant drive to force people out of the corporation into other areas . It's a paradox. Now we're reading documentation that states there is going to be a lot of competition for workers during the next 10 years. Documentation such as *Workforce 2000*. So, AT&T, like the IBM's of the world, has cut people in order to compete more effectively. However, we're going to have to compete in the next few years to get people back to service our needs. We're in a catch-22 type of situation. When do you hire those people? Right now? Well, you can't hire them now, because now we're competing with the Japanese and everybody else.

Right now, in order to bring the technology to the forefront quickly, AT&T will buy up a corporation. AT&T bought Sun Microsystems. We go into the silicon valley and we buy up places. We have joint ventures with IBM. We have joint ventures with Memorex. One big division of our computer systems group was just sold to Memorex. All of those people were told that you no longer work for AT&T. You've got to compete for jobs if you're going to stay with AT&T, or you can interview with the new corporation, Memorex. It sounds a little bit discombobulated. There is a lot of risk involved. That is the market place that we are dealing with.

We were just talking about my friends at IBM and other places. They are, for the first time, dealing with layoffs and early retirement. We found people who only had 5 years of service with the corporation opting for early retirement to get out of the company. It's great for the company to do that. At AT&T in the early programs, people were offered three times their annual salary plus benefits to leave the company. If you were making $60,000-$70,000 and someone offered you a little bit more than a quarter of a million dollars to leave the company, that's kind of attractive. Especially when you say, "I can go back to the University of Illinois or some place and teach, while I have $250,000 in my bank account." So we are counting on that type of thing to happen. The only thing is that it causes a lot of morale problems within the corporation. We have a big morale problem.

When we talk about globalization, AT&T is now going around the world trying to establish itself. Since we cannot compete effectively in this country and build telephones the same, I would say about 80% of our telephones are now built in Indonesia. If you look on your phone, sometimes on the bottom you will see it says "Made in Indonesia." Or, it will say, "Not made in Japan" because AT&T believes that if the Japanese will not allow us to come into their telephone technology, we're not going to afford them the benefit of building phones for us. However, we do have some joint ventures with Mitsubishi and some of those other corporations. When we go into a joint venture with Mitsubishi, instead of sending one person to Japan like we do, it's not cost effective to send many people, Mitsubishi will send 50 people to Chicago. It's very difficult to compete with that type of situation. They come into our areas and our plants and they'll work 20 hours a day to get the job done. Many of our people are union people who are not going to do that. So, AT&T is forced into a position of saying, "If you don't do that, then your Japanese counter parts will do it. They'll work 20 hours a day for half the money we're paying you." So it has caused a situation.

We're sort of contributing to the very thing that everybody's talking about with foreign interests buying up our big corporations. And even though they haven't bought AT&T and IBM, what we're doing is serving up big pieces of pie to them. To me it's the same thing and it causes a problem.

The students that you train come out of the University of Illinois and we're asking them how large of a salary they require. They have these grandiose salaries they want to start with. We don't have to pay them that kind of money. Now there are certain things we can offer them. An $18,500 salary with benefits on the side.

But there are still some other opportunities where we have not gotten foreign interest to help us. Those jobs are still there, especially in the management end of the business. We find that a lot of our people come in with a good technical background. I mean, they're great in physics, they know it inside and out, but we cannot promote them to the higher realms of management. They don't know how to manage people. They don't know the dynamics of management. They don't know how to deal with the humanistic elements.

One of the courses that we deliver is called Leadership for the Future. I do have a few brochures that I'm going to leave. In this particular course we try to instill in our managers how to be principle-centered individuals. Even though AT&T is competing in a global marketplace, they try to instill the importance of being honest, looking at yourself and dealing with stress levels. We feel that people who have good feelings about themselves, who are in charge of their own personal growth and development, can deliver a better product for AT&T, and as a result, deliver better service to our clients around the world. That brochure is here and it lists the seven habits of people who become more principle centered.

AT&T has decided that maybe the university structures and the schools around the country aren't giving them the product that they want. We have now formed what we call the *University of Sales Excellence*. It operates out of Dublin, Ohio. AT&T is establishing its own university. We have four colleges in that university with four deans. People who are hired on or who are members of the AT&T family go through what we call a specialized curriculum whether it's package switching, learning about the network, products and services like PBXs and computers or just for their own professional development. It's a course that takes anywhere from 1-3 years. When you finish that course, AT&T awards you a "degree." That degree will determine if you are promotable or if you can move throughout the company. If you do not have that degree, you are not eligible for promotion. In essence, they're going to use the *University of Sales Excellence* not only to train their people, but to determine how far you can go in the corporation.

AT&T is also cross-training their employees because of down sizing. They want their employees to be more technical, but they want them to be more professional as well. AT&T wants them to be able to step out of Bell Labs where they are building artificial intelligence mechanisms and step into a management role in personal or human relations. AT&T wants them to be able to go throughout the corporation and take their skills with them. I came out of the marketing organization. I really didn't want to leave marketing. The money was great, it was fantastic. But, the corporation said, "We need you, because you have the educational background, to go to corporate education and training." Well, when you look at the bottom line over the past few years and you look at what the people in training make, I didn't want to go to corporate education and training. I wanted to stay in marketing. AT&T came back and said "You don't have a choice, either you go over to corporate education or you'll be marketing yourself."

AT&T decided that those persons in other fields who do not go through the *University of Sales Excellence* will be sent out into the school systems, Chicago's school system for example. AT&T is meeting on a regular basis with those principals and teachers. They are saying to those high school principals, you've got to give us this kind of product. You're not developing people to be what we want them to be, especially those students who are not going to college. Those opportunities are almost few and far between. Now, rather than take someone out of high school and develop them within AT&T, unless they are willing to work for almost crumbs, AT&T selects college graduates that we can get for a cheaper cost.

Managing professional growth, basic negotiating skills, presentation techniques, I do that for a specific salary at AT&T. Because we have so many people to train, we have to increasingly rely on venders and consultants. I may have a consultant in another room delivering the exact course that I am delivering. That consultant will make $700 a day. We have some consultants who put in 10 days of work for AT&T and take home $7,000 a month plus expenses. Those of us who have these talents begin to reexamine our careers. We begin to say, "Wait a minute, why should I work for X number of dollars when my counter part, who's a consultant, is making $100,000+ for the same thing that I'm doing?" We're beginning to reexamine, even those of us with degrees, what we are willing to give AT&T, what we expect from them.

Of the marketing people that work for AT&T, the experienced level has dropped dramatically. A lot of our veterans have left the company. They opted for early retirement. There is a back lash from our clients. They are saying that when Joe Hill was here, he brought a wealth of talent, he knew me, he knew my job, he knew everything was professional. Now, you send this college grad out to me and I have to educate him while I pay you a big fee. So we're not getting the kinds of results that we really want, even though we have greatly decreased our payroll costs. So that's one of the ramifications.

One of the last things I just want to say is that we're finding that more and more of AT&T's employee base is foreign in nature. Our manager in Indonesia and all the people who make our telephones. We're making conduits and things in Mexico, places where they don't have unions. We're finding that the Japanese are really hard to turn down when they say it's much cheaper for you to buy chips from us in bulk at a reduced cost. That's going to really help your bottom line. The tragedy is that our plants in Columbus, Omaha, and Shreveport, places like that, are shutting down. If you're a place like Shreveport, Louisiana, where you really depend on AT&T, when a plant shuts down, it would be just like the University of Illinois leaving Champaign-Urbana. What would happen to Champaign-Urbana? What kind of place would it be? It's the same sort of ramification. That's basically where we are.

AT&T has approximately 38 training organizations based on services that we're delivering. Whether it's technical, PBX, computer training or just professional training, we have a separate brochure for our managers that we call third level and above. These would be our district and divisional managers. We have a curriculum for what we call our first and second level managers. We also have a curriculum for our occupational employees. Believe it or not, AT&T has more managers than it does occupational employees. The reason that they did that, is that it is much easier to be in concert with government regulations.

That was just a brief synopsis of the world of AT&T and the type of people that we're looking for at AT&T. We have down sized tremendously. We have down sized in one week, and at the end of that same week, hired many people back from different corporations. We are hiring a lot of our retirees back. Some of our people are getting all of the benefits from AT&T when they are hired back as a consultant. We can't find the people with the skill level to take care of our business during this period. So again, it's back to that catch-22 situation.

PROJECTIONS FOR THE FACTORY OF THE FUTURE

Stephen Lu

As Scott mentioned, I am a researcher working in manufacturing and design automation. When Scott called and asked me to give a talk to this group of people I was not sure I was really the right person. First, I'm not an educator and I'm not really working in the research areas in education. Strictly speaking, I am not even the full product of the education system in this country. I only received my graduate study training in this country. All my previous training was in my home country of Taiwan. So, I really wasn't sure what I should say to a group of educators. I didn't promise Scott at the beginning, I thought about it a couple of days. Then, two factors came to my mind and changed my decision. I called him back and said, "Yes, I'm willing to take this challenge."

First, I noticed that I'm am not really supposed to say anything about education. That's good. I am suppose to give you a picture of the factory of the future. I work with factories everyday, trying to bring a better future for them through my research. So, I can talk about that. Particularly with emphasis on the future. As such, I will not take a major responsibility of whether what I say is correct or not correct.

One portion of the factory information I've been working on is quality. Throughout my several years of research in this area, I have found that if you want to have a good quality factory, input is the most important part. This input will be the physical input, the materials we purchase from our vendor. An important part of our input in our factory is the workforce. This relates to education. I have found that if we do not do a good job in preparing our workforce no matter what kind of factory the future brings, we will never be able to reach there. Therefore, I am very delighted that I am given this opportunity to speak with a group of educators and I will try to explain to you how I see the development of the factory today and the future. Then, we will come back to see how we prepare our workforce for such future factories. That is my motivation for coming here and exchanging ideas.

Certainly, when I speak of the factory of the future I will be biased toward what I know best. So, the majority of my talk will be centered on technology and employee tasks. I will start my presentation by talking about the direction of our industry. This is a projection. Then, I will focus on one example of technology which I will call *knowledge processing technology.*

These days you see factories processing materials. They take materials in, they ship materials out. We also so see a lot of software warehouses. They process data. They take data in, they ship software out. In the future we will not only have a materials processing factory and data processing factory, but also a knowledge processing factory. We have to really look at our knowledge in making a decision as a very valuable commodity. We should create a factory to develop such a valuable commodity to increase its utility. I will be focusing on an example of new technology which is called knowledge processing. I believe this technology will play a very important role in the future of factories. Next, I will introduce you to emerging automated tasks. These days, maybe some of you heard from the TV or read in a magazine, everybody is talking about concurrent engineering. Simultaneous engineering, designed for manufacturability. What is that? That is a very interesting idea gradually being implemented in most major industries. I am going to use this as one example to give you some idea of how technology has changed in factories. Then, I will briefly touch upon how knowledge processing technology can impact on this emerging technology. After that I will give you some examples of several national efforts and international efforts which are aimed at providing better technology and support to the concurrent engineering of global product development. I believe this will shape the factory of the future. Finally, even though I am not a researcher in educational areas, I think I am obligated to say a few words concerning the implications for education. This is the overview of my presentation.

How do I see the factory change? If you look at factory evolvement, there is one key technology that has made a lot of impact in the past three or four decades. That is computer technology. Before we knew how to use the computer most of the factory operations involved manual processing. We build and operate machines. We make products. Those industries are labor intensive. We have been there for a long period.

Then, someone invented the computer. Someone brought the computer to the factories and tried to automate many of the labor intensive tasks. For example, we built a lot of robots. A robot is nothing but a mechanical hand or a mechanical device that will help you to complete your more repetitive tasks. So, the impact of computer technology on factories actually changed the characteristic of the factory from labor intensive to material intensive. What I mean here is labor will really not give the competitive edge anymore. You can now use a robot to replace your labor cost and labor force. Whoever has the best material, whoever can produce the best materials will be the winner in the market. These days you walk into a factory and see every machine has three or four computers sitting next to it. You see not only the physical machine but the computing machine.

Industry has actually moved to another level. That is because the computing machine generates a lot of information. Information such as the inventory of the factory, the schedule, the due date, the status of the machine on the factory floor. So you see, not only has your physical machine kept producing a physical part, your computing machine keeps taking data in and putting data out.

What we see here is actually a change in industry characteristics from *material intensive* to something I call *information intensive*. If you walk into those high tech companies, large corporations, you will see every potential work station has a computer taking the senseless data out of the process while keeping the critical data. We see the factory has changed. The factory now is information intensive.

There is a problem with generating information. That is, if you have too much information it does not help you make good decisions. Information will help you make a decision only up to a certain point. After a certain point you will be overwhelmed by the amount of information. You have lost the ability to make the right decision. This is an information explosion.

When I was at graduate school I wrote a large engineering analysis program which runs about twenty-three hours on a Cray machine. At the end of the program it would give you a very large print out. It did not help. It was just information. It does not help me make decisions. The challenge now is how to take advantage of a powerful information processing machine. We want not only to generate and store information, but we want to use this information to make the right decision. The right decision allows us to run our factory more effectively and efficiently. That is the next challenge.

I think you see this already happening in large corporations. They are switching from the *information intensive* stage to the next stage which I call *knowledge intensive*. That is, those with the best knowledge, those who have the best way to utilize what they know, will be the winner in the market place. Those who buy the best computer will no longer be the winner. This would probably be the case today. It certainly will not be the case tomorrow.

Certainly materials are very important but, the cutting edge does not mean labor, material, or information. Rather, the cutting edge is knowledge. Actually things reverse because, knowledge only matters in the workforce. So we now switch our focus back to the workforce.

You can see as things move they eventually come back to the critical initial factor, human beings.

Summarizing this evolution, I see the impact of computer technology has moved U.S. industry from labor intensive to materials intensive, from information intensive to the next evolution of knowledge intensive.

It is very interesting to see that the activity of the factory has also changed accordingly. In the early stages we did manual processing. We processed a lot of physical parts. Then we moved to materials processing. The automated machine processed materials. Then we began data processing. These days large corporations have a large data processing department. They are processing data. You really cannot get away from dealing with data. So, a large amount of the factory workforce is spent on processing data. The next challenge will be how one processes knowledge. As a matter of fact, one of the missions of my research is to create a conceptual factory of the future. That factory will take the commodity of knowledge and do something with the knowledge, producing knowledge that has a higher utility than the input knowledge. You can see the type of factory evolve from processing a physical entity to processing a more conceptual entity. Certainly, the processing of a conceptual entity does not mean that those factories that process a physical entity will disappear. They will still be there. If you do not have a good methodology for processing a more conceptual entity to manage your factory, you will not be able to survive in the future.

Numerical control micro-programming, micro-control programming, computer controlled numerical machines, robotics, CAD-CAM, and artificial intelligence are the key technologies that have made, or will make, an important impact on this evolution. Artificial intelligence's impact is still very limited. There is a lot of work that needs to be done in order to make this evolution a reality.

These days you hear a lot of people talk about the flexible factory. We want to have a flexible manufacturing system. What do we mean? Actually, flexible manufacturing is an attempt to change our factory characteristics.

A good example is to look at the automotive industry. When you walk into an automotive factory you see a huge transfer line. That is, if General Motors wanted to build a car they would invest millions of dollars to build a specialized production facility. They would have work stations one after the other with a very specific conveyer in between. Each work station will do nothing but one specific, single, repetitive task. They have automated the work on a transfer line. This we call *part automation*. That is, you look at exactly what you want to do to complete this job, write a computer program for the computing device to exactly repeat those tasks. However, we have found that the Japanese are better at automotive production. Why can we not compete with them? Why do we put millions of dollars in building this beautiful transfer line which still cannot produce a better quality than they can? The difference is that they have a different philosophy. Their industry is one of *flexible automation*.

What is flexible automation? The idea of flexible automation is to have a factory facility that not only can produce the product you are doing today but also the one tomorrow. If you have any reason to change the product, you can, without great effort, reconfigure your factory facility to produce the new product without building a new transfer line. Now, this idea is a very attractive idea, but it is very hard to achieve in reality.

Do you want to build your factory to produce one single part forever? Do you want to build your factory to produce one single part for a given period of time then, after making enough profit, junk the production line and build another one? That has been the way we have done business for the past fifty years.

In a flexible factory the initial investment is higher. You want to have flexibility but the factory is structured so that it can be reshaped to perform different jobs. Today you make large cars, tomorrow, because of the energy crisis, you want to make smaller cars. You can use a similar production facility to make a smaller car. This is flexible automation.

If we are to move from information intensive to knowledge intensive we have to go one step beyond flexible automation. I like to call this *intelligent automation.* That is, not only do you want to use the computer to replace our action, we also want to use the computer to help us make the decisions. We want to put some of the human intelligence into a computer. The computer must not only execute our order, it must also help us decide on the proper action. More importantly, the computer with intelligence may help us deal with a crisis.

In the future you will find the most valuable worker in the factory to be the one that can deal with crisis. The machine job(s) will most likely be run by a computer. Unless one day we can build a machine that truly has intelligence when dealing with a crisis, we will still need factory workers. You will need a different kind of worker than the worker we have today.

The rest of my talk will focus on intelligent automation. If you look at any factory, it doesn't matter what they make, there are basically three levels of tasks people have to carry out. The first level is a facility level. You have to arrange your machines. Make sure the machine is put in the right place. Make sure the machines talk to each other. Make sure you have parts moving from one machine to the other machine. There are a lot of physical resources spent on the factory's facility level. Because of the existence of this facility you're given a lot of information. You have to train another infrastructure to support the management of information. Above the information level you have another level to make decisions. Suppose your factory is shut down today due to one failure within a machine. What do you do? Suppose you have a due date tomorrow and you are still short of parts for delivery. What do you do? There are a lot of decisions that need to be made. The decision making is based on the information you collected. This information is a reflection of the factory facility.

You can see there is a gradual change in automation focus. This is from research. We spend a lot of effort in research trying to automate facility level tasks in factories. We have to spend a lot of effort trying to automate information. I think in the future you will find resources spent on automation efforts, trying to help us make better decisions.

This is not a prediction made only by myself. Look at the fifth generation computer project that Japan has put up as their national goal beginning in 1980. This was ten years ago. What is the fifth generation computer? Compared with the fourth generation computer and third generation computer, the fifth generation computer is different. The fourth generation computer is a faster and larger computer than the third generation computer. The fifth generation computer is a different computer than fourth generation computer. The fifth generation computer has nothing to do with size and speed. The basic difference in the fifth generation computer is the processing of knowledge. The fourth generation computer is a huge super computer, but it is still only processes data. Why did Japan want to do this? The basic idea was instead of selling automobiles, cameras, and videos, they sell tapes which are plugged into the factory to make cameras, automobiles, and videos. Those tapes have knowledge. Japan wants to do these kinds of things. It is not really something that just happened yesterday, it has been a natural trend in some other countries.

I think right now that this is the trend that will have a very major impact on the industrial evolution. You look at Adam Smith's theory on a nation's wealth. The wealth of a nation depends on its resources, depends on its land, all these different things. If the goal of the fifth generation computer is realized, it will break that theory. The wealth of a nation will then depend on the ability to draft, process, store, and sell knowledge.

There are two key points, one is called flexibility. As I mentioned earlier, we want to have flexibility. The other is integratability. The basic idea is to have a factory that is flexible. One thing that makes the human being intelligent is that it is flexible. Can we make the computer flexible? If we cannot make the computer flexible how can we expect to have a flexible factory? That is the first challenge. The second challenge is the integrated factory.

What do I mean by an integrated factory? The integrated factory is more than an interface between machines. The integrated factory means that before one reaches a final decision about a product or process, one will have an opportunity to check with others to insure their input is truly embedded in the decision. This is what we call an integrated solution. Today's factory does not do that. We require an interface solution. This means there is a huge task broken up into sub-tasks. I will do my part, you will do your part, and then we will exchange results. This is called an interface approach. A lot of the time we are hurting so badly in our factory productivity due to a lack of integration. We do not interface. We end up debugging the whole process and are not able to deliver the product in a short period of time.

Let me give you some idea about the real challenge of flexibility and integratablility. I will lead to a conclusion that the current computer technology which focuses on data processing cannot do the job. We need a different kind of computer, a knowledge processing computer.

First, let's look at flexibility. If you build a factory facility that is very good at one particular task, but what you really desire is this facility to do several other tasks, what do you do? You make an exact copy of a task, then make specific changes in those copies. You end up storing five scenarios in the computer. If you want the computer to do ten scenarios you store ten, increasing the size of storage again and again. We always say you have more data than the largest computer can process. If we want more flexibility we buy a larger computer. Ironically, we are going the wrong way. The basic entity, the computer, is processing data. What is data? Data is just a specific instance of a particular event. Unless, in the future, I expect that exact event will occur so that I can retrieve the data and find the solution, it is not really useful to store data. What I really need is the ability to deal with variations of that data. I need flexibility. Someone said, "Don't worry, store more data." The notion is that somehow you will have a large enough data base to find the solution. No, we are not going to find the solution. The dilemma we are facing here is that computer processing is rigid. No matter how big your processing machine is, the unexpected possibility pops up. The more rigid the data processing the more rigid the results. You don't have flexibility.

How about integratability? These days we buy a large computer and have a distributed work station for every engineer. We break down their task. They carry out their own task based on the assumption of how other people do their jobs. They never make a phone call to see if they are correct. They carry out the sub task then give it to someone who puts it together. This is very expensive, but that's the way we do it. As I said earlier, that is not a very good way to do it. What we need is to be able to have a computer that integrates the ideas of all workers. Try to look at other people's perspective. It is like you holding this meeting. The purpose of the meeting is for you to understand what each other is thinking. It is that kind of computing environment we will need. Now, you say, "What does this have to do with the computer?" It has a lot to do with the computer. The basic requirement to achieve an integrated solution is to be able to comprehend each other. The comprehensibility is the key.

Let me bring you back to my earlier point. Can you comprehend the data? You cannot. If I give you a data base, it only makes sense to you if you know what is there. Whenever you look at a set of data you actually apply your own conceptual model to interpret that data. The data, when stored in the computer, has no meaning. Data itself is totally incomprehensible. I don't know how many of you have any experience running those large data analysis packages. If, in the middle of execution, you stop the computer and ask it what it is doing, the computer does not know what it is doing. It doesn't really have any idea about the task. This is another dilemma we are facing. If we keep using computers to process data which by itself is incomprehensible, there is no way we can achieve an integrated solution. You say, "This is really bad. Is there no hope?" The hope now is to see if we can change the basic commodity, the basic entity of the computing process. The simple requirement of this basic entity is first, flexibility. Secondly, it has to be able to be complimented by a human being or by another computing processor. Flexibility and comprehensibility are the keys. If you have these two you can achieve a very flexible factory and a truly integrated factory. There has to be a lot of research these days to address this issue.

This leads to an introduction of a whole new technology called *knowledge processing.* The basic idea is that in addition to processing data we also process knowledge. That is the key idea. Remember, I said in addition not instead of. I do not mean that data processing is bad, I simply mean that data processing alone is not sufficient.

If you will look at knowledge processing after the natural evolution, the goal was to make better materials with better utility. Now we use the factory to process information. Every factory has a huge data processing department to process information. Why not use our factories to also process knowledge? That is the basic idea.

The basic goal for knowledge processing is almost identical to the goal in materials processing. In materials processing you take a piece of steel and test its hardness. If the hardness is not sufficient for your application, what do you do? You put the piece of steel in the furnace. You have increased the utility of that material. You can do the same thing with knowledge. You give me a piece of raw knowledge which by itself has some utility, but because of your specific application needs, it is insufficient. What do you do? You put it into this knowledge processing furnace which we are building. This furnace will do something that will change the application of that knowledge, change the property of that knowledge. The output knowledge can solve your problem. It has higher utility.

I should give you an example of one kind of raw knowledge that we constantly face. This raw knowledge is called a simulation package. That is, we study the physics of a process. If you look at a large program, how do you use a large program? First, you have to find out all its inputs. Put the inputs in, hit return and the program gives you the output. Have you ever encountered a case where some required input is unknown? Have you ever encountered a case where some of the input is not there but some of the output is there? Sometimes you know partial output but not the input. Well, if you have that case and I give you a traditional simulation package, you stop there. This is a case where the given knowledge doesn't have enough utility for your task. It is my idea to build a program based on machine learning from artificial intelligence. We can take your simulation package which is raw knowledge and reprocess this knowledge. The output will be associated with use. If you have partial output and you put it in the data base it will give you back the input. You can do it both ways.

The output which is in a raw form still says pretty much the same thing only in a different representation as a result of a different interpretation and different utility. We have been using this system to support a lot of engineering work.

A lot of times you're given a simulation package which has a fixed level of detail requiring all this input, but on day one of your decision making process you don't even know this detail. So, you have to stop using this package. You have all this detail in the wrong package. The problem is we do not know how to put this simulation package in a linear structure. So that, when you are at a very abstract state you use an abstract model and as you get into detail you use a detailed model. We don't know how to do that. Now we have a methodology. If you give me an input simulation package, I can produce a linear model according to the desired level of acceptance and accuracy. So that if you are only concerned with two of ten variables I can give you a package that is only concerned with two variables. Certainly this produces lower accuracy, less detail. This gives you some idea that there is a lot more we can do to change the representation of knowledge. The important thing I want to mention here is that this kind of research, knowledge processing research, has different characteristics than typical traditional research. Traditional research emphasizes finding new knowledge. In knowledge processing technology were are interested in finding a new way of using new knowledge. That is the idea of knowledge processing. I personally believe that if you have new knowledge and don't know how to use it you should not even bother. It does not help you.

Maybe I should tell all of you my personal dream. I would say that in the future factory we will not need three shifts of factory workers. Ideally we will just need one shift of factory workers with three shifts of a factory brain. What is the idea? You buy a lot of computers these days for the factory. During the day, 8 a.m. to 5 p.m., the computer is running. Your factory worker is running it. At 5 p.m. your factory worker goes back home and, most likely, you shut off your computer. Your computer becomes idle. That is bad. You are paying for the computer anyway so why not have the computer process all of the data you have accumulated during the day? Why not have the computer try to find a relationship of all the events that were recorded today? In that way, tomorrow morning the factory worker turns on the computer, the computer states what it saw happen yesterday. Wouldn't that be nice? That would be very nice. This is the dream I have: A one shift factory worker with a three shift factory brain.

It is very interesting that these days many corporations worry about productivity. Look at what they do. If they want to have more productivity they buy more computers for their engineering staff or they buy very expensive telephones for their managers. Why? The computer does not really help your productivity that much. It would be nice if in the future both the manager and engineer could use one single kind of device.

Just one month ago we held a special workshop in Yugoslavia. We spent a whole week with people from Germany, Japan, and some people from the USA. We spent the week discussing the foundations of knowledge processing. This is the concept that has been accepted by the community. The basic idea is that we want to build a conceptual factory. This will be a factory we call a knowledge processing factory. The raw material comes in as raw knowledge and a better knowledge comes out.

Why do we want to do this? How are we going to make an impact with this thing? Well, you really cannot make an impact with these things and convince people to use these kinds of things by saying it's going to help you. Where is it going to help us? Recently, about a year ago,I started focusing on knowledge processing technology for concurrent engineering. You will see later that if you really want to get concurrent engineering, you will not be successful unless you get into knowledge processing. If you keep processing data you will never be able to do concurrent engineering.

Let me switch to the second focus of the program. Concurrent engineering relates to how we develop a product. How do we develop a product? Someone has an idea, they want a nice thing to write with. The idea of a pencil comes up. Then, the designer uses his knowledge to build the shape of a pencil. He throws it over the wall to the process planner. The process planner looks at it and says, "We need to buy these, schedule these, run the machine, ..." He writes down all these process sequences and throws it over the wall to the operator. The operator follows the instructions. By the time the operator received the instructions from operations, he had yet to receive the necessary machinery. So, he sends the request back. He says, "Wait, let's buy the machine first. I am not going to do the job until you buy the machine." So, you can see there is a lot of fighting between these departments. This has been the traditional case for a lot of corporations in this country for the past twenty or thirty or fifty years. Now, this way won't work at all. The computer has a much better way of doing things. You can introduce your product on the market much faster Also, because of the competition of the market, it does not make sense to take ten years to develop a product that will only last one year on the market. You don't want to do that. So, you end up not introducing any new products.

People have finally realized the real competition in productivity is how fast you can push a new product out on the market. You don't want to go through a long process of recalls and debugging. The traditional way is not supported. Your competitor, maybe Japan, has a very nice way to do these kinds of things. Their development of an engine is about one third the time we need to develop an engine. How can they do that? Later on I am going to give you some reasons. I am also going to suggest some ways that we can do the same. The important thing is if you do not have a very nice product development methodology you will probably lose the market.

People say, "In order to increase our place in the market we need to do better." This way has been very popular in the past five years. Designers say, "You guys come over to see my work, my work is really tops. You shouldn't expect that I should only listen to you, you listen to me." The designers believe you should manufacture from the design viewpoint. On the other hand manufacturers believe you have to design from their point of view. Actually, you see many papers published in the last five years talking about designing for manufacturablity, or manufacturing from designability. Actually, that is not a good way to do things. The key concept of product development is not you listen to me or I must listen to you, it is break down the wall. That is, whenever you have an idea, put it out on the table. Let's look at it.

Last year I visited Toyota research laboratory. I was very impressed. They invited me to one of their review sessions. They call them product review sessions. Every week they have product review session. They request even the young engineers to place their ideas, even very primitive ideas, in front of those people. After that meeting I asked them, "Who are those people?" I was very impressed to find out they ranged from company executives, salespeople, factory worker, senior designers, and senior processing engineers. I don't understand the language therefore, I don't really know what they are talking about, but these ideas will be examined by many different perspectives every week. No wonder that by the time the product matures the contribution from different perspectives is already there. This is the basic idea of concurrent engineering.

In U.S. industry, as a research engineer working at a research and development center, I invent a really nice idea. I report this to my boss. Most likely, my boss will ask me to write this down in order to get a patent. Then, this paper will be shipped to another product company called the development center. The development engineer will look at the document and try to build a prototype. It is then shipped to another product company called initial product realization. They build the whole product line. By the time you reach the product, it is ten years later. Toyota does it differently.

If you are a Toyota research engineer and develop a product, you report it to your boss. What will happen tomorrow? Tomorrow you will be moved. You will be moved with your idea from the research department to the development department. You will carry out the development with the help of the development engineers. After you finish the product development and report to your boss, you will be moved again. They move people from organization to organization through the whole process. They even send you to the sales office to watch how the product is sold. Then, after you have finished this process they move you back to the research and development center. Look at what has happened. Look at the experience you have accumulated in the process. You will be a much better research engineer after this process. Again, this is concurrent engineering. You may think that this is simple, that we should change our organization and do it the same way. No, it will not work. This is a different country with a different culture, different organization and a different tradition.

The basic essence of concurrent engineering is that you want to have the ability to integrate different expertise. You want to have the ability to coordinate different resources. You want to be able to communicate with each other. Finally, you want to be able to achieve a very common solution in a very cooperative way. That is the basic essence.

This is really the problem of a lot of designs these days in the factory. The designer makes the decision early on. Why? They feel obligated to make a decision. They don't call people, they make a decision. Later on, the planning department and manufacturing department spend all their days fighting this decision which was made arbitrarily. That is very ridiculous but that is what is happening in a lot of large corporations. The basic idea of what we should do is to simply break down those lines. Don't even think that there is something special about design or process planning. Everybody is equal. Everybody is called a product engineer. I really don't want to call anyone a designer. Therefore, the division of such costs will be broken down.

The decision can then be made in an integrated matter. In some cases a designer really doesn't have a very good idea if the product should be round or square shaped. If he doesn't have a product engineer sitting next to him he may just choose a round shape. Why? The round shape might look better. If the process engineer is sitting there he can say, "I do not have a device to make the round shape." Just that simple voice will remind the designer. He will say, "Ok, if you don't have the device I can use square shape." It is this kind of scenario that will decide the overall productivity of our factories.

I have said this could be an organizational problem or a cultural problem, but I personally believe the computer can help us to facilitate this problem. We must build a better computer than we have. I don't mean a larger computer, but a better computer.

If you look at current computer technology, it does not support cooperation at all. The more computers you buy for your engineers the less they talk to each other. Every morning they get into their own office and start up their keyboards. They do not talk to each other. That is very sad. If you look at it, the more computers you have, the less you talk to one another. At 8:00 a.m. when you walk into your office you start working with your computer and by 5:00 p.m. when you walk out you have spent almost five hours with that computer. Well, that dumb computer is as dumb as it was in the morning. It did not do anything. In the mean time, you spent twenty minutes having a cup of coffee with your colleague and learned a lot of things. He or she learned from you. Can we get a computer to do the same thing? So you can see we are really putting our emphasis in the wrong computer technology. What we need is to have a computer that can support cooperation among a group of people. We want to have a computer than can learn and improve itself. That is the key.

If you look at the essence of concurrent engineering, cooperation, communication, integration, coordination, there is nothing like this. You say, "That is not fair. Now that we have computer E-mail, we do conference with one another." No you don't. How many of you read all this junk mail? I don't. So you are actually not reading this mail. We are talking about a technology that is built upon networking, but is much beyond networking.

I would like to show you some of the national effort in building computer technology that can truly support cooperative work. This is a copy of the first page of a recent National Science Foundation report. NSF invited a group of very respected researchers in computer science to take part in a workshop. They came out with this workshop report. I like this report very much. If you are interested, I can leave a copy with you. The report is called *Towards a National Collaboratory*. They invented a new word. What does that word mean? The word can be read in two different ways. The first way is co-laboratory. This means people can work at remote facilities as if they were located at the same place. This is actually happening.

Last year I was in Oslo, Norway. I was making a presentation. I told them about the nice software I had developed. I could tell people did not quite believe me. I presented them with a challenge. I said, "If you have a network, let me call my students. My students will run a demonstration on my computer and, through the network, we will display the results on your computer." Surprisingly we did that. I made the phone call to my students. We had to run the program on our computer logging in their computer as one display terminal. Things were slow but they could see the window and they could see how this worked. This is a good example of collaboratory.

Next, we will talk about another interesting idea. We will talk about how people can work with each other. The basic idea is that they talk about a research agenda leading to a national collaboratory. A resource that would use networking and computing technology to support remote interaction. There are basically two major items in this initiative. One is the networking ability. You must have a network before you have anything. The other is computing technology. The computing technology they talk about includes data base management, including a lot of artificial intelligent techniques. This is really the essence of knowledge processing.

The interesting thing is that in their report they have this huge chart. They think that such collaboratory can be applied to some computer engineering and some other projects like the human gene project, the global ecology project, the high energy physics project, and the super conducting-super collider project. They believe that it is necessary to have such collaboratory to support people working together in an integrated fashion. As a result of this initiative, NSF made a special proposal. It is interesting that we talk about a special initiative in a coordination theory of technology. Actually I can underline these words, *coordination technology*, as the future challenge of factories. If the factory workforce cannot coordinate with each other, if they cannot work in a very cooperative manner, we will not have the future factory we desire.

Earlier I told you that in 1980 Japan announced their national project of the fifth generation computer within ten years. Now it is 1990 and you may wonder what will be their new announcement. In about October of last year, Japan announced that within the next ten years they will spend 15 billion US dollars to develop a project. This is the front page of their announcement. It is called Intelligent Manufacturing Systems. The interesting thing is that this time they want to do things differently. They want to do a joint international program rather than their nationally based program. I think the basic motivation is to balance the trade imbalance. They want to put some money into other countries so that everything looks better on the accounting books. They are thinking of building three major research centers. One will be in Japan, one will be in Europe, most likely Germany, and one will be in North America, most likely it will be here. Last week we received a group of visitors from Japan in our laboratory and now they are sending a different group of people to a different country.

Why do I mention this? This is a vision. Japan thinks in the future, the year 2000 and beyond, they must have intelligent manufacturing. The manufacturing system should be efficient, flexible and intelligent. They have several pages describing the necessary technology. They sent out a communication stating manufacturing technology has no national boundary. This is so everyone will contribute their good ideas. This is just my personal comment, I think this is a very tricky game they are playing. When we talked with their representatives, they really did not tell us anything except to say they have a check for $15 billion. They travel around the world and collect ideas.

The future plant may be described as follows. First, there will be a very strong signal of global product development. In the future you will see that design is done in North America, process done in South America, sales office in East Europe, and maintenance office in Europe. You are really talking about a global product market. Therefore, satellite communication technology becomes the key. Then, because of the central communication capability, you can distribute your decision into a larger location. In the mean time, you can pull all locations together to coordinate your decision before making a final commitment.

The sales agent and outside subcontractor deal with your supplier and research and development center while the technical office people worry about logistics, legal issues, accounting, the distribution people, and the real factory which has a lot of physical devices. Japan is now committing $15 billion to make this a reality within the next ten years.

Let me conclude my talk by illustrating how I see this change in the factory of the future impacting on education. First, I think you will see a major change in the type of workforce we will need. Unavoidably we will have fewer people operating a factory. The roles of these people will be much more critical than the factory worker of today.

One of the characteristics we find in a highly automated factory is if they run smoothly, fine, but if someone makes a mistake, the whole operation must be shut down. You cannot afford to make those mistakes. The quality of the workforce becomes critical. Even though there are fewer people in the factory, they will have to be the best.

I visited a factory which I think is the best example of the factory of the future. This is the factory for Japan's largest manufacturer of controller machine tools. They have a beautiful plant at the bottom of Fuji mountain. When I walked into the plant I noticed the whole factory was painted in a shinning white color. It was so clean. Remember when we called factory workers blue collar workers? They were dirty. There this was not so. The factory only had people on the floor two hours per day. The rest of the time the factory was automated. This is the kind of factory you will see. You will find the factory worker of the future will have to be the best.

The quality of a decision, not how strong they are or how well they can turn a knob, becomes the most important requirement for a factory worker. Physical manipulations will be done by a robot or replaced by computer. You will not have a good factory worker if that person can only tune a knob very precisely and cannot deal with variations in a situation. The most important quality for our future factory worker will be their ability to learn. Also, they must have the ability to apply what they learn to solve a problem. They will be a planner and problem solver; not just a physical worker.

Working with a computer will be a must. This has almost become a language that people will have to speak in the factory of the future. This is already happening now in the engineering research area. If you want to do engineering research you must be aware that computers don't speak the same language that we do. The same thing will happen in the factory very soon. You are going to see this become the common language in factory communication.

The next important ability is the ability to work with each other. I think the best worker in the factory of the future is one that cannot only apply their own knowledge but can apply other people's knowledge, can listen and can be a very good team player. This actually is one of the major drawbacks of our current educational system. In engineering we train engineers as a specialist. Later they end up working for an MBA. If they want a higher salary they have to come back to a business school. What is wrong? I think we did a poor job. We need to train an engineer not only to be a good specialist, but also to be a good team player and team leader. We don't train them that way. I think that is very sad. If a student of ours wants a high job in a company they have to go elsewhere to get an MBA degree. We really have to shape up our education curriculum to produce not only new technology but knowledgeable people. That is the key.

Education should cover more than education. We should put a lot of emphasis on re-education. We are looking at people who have been working in a factory all of their lives repeating a physical skill. Unless we want to lay them off we have to retrain them, we have to make sure that they can do other things. The re-education process is a very critical role for colleges and universities. I would like to see us open up our door to company employees and have them come back for re-education. When I say re-education I do not mean "on the job" training. We are not in a position to teach them how to operate a Cray machine. If they want to learn that they can go to some particular company. What I mean is having them come back to school for one or two semesters to learn something exciting which may not happen tomorrow, but will happen next year. I think this is a very critical role for an educational institution like ours.

Recently I read a report concerning a special program called the Manufacturing Leadership Program. They had a team of experts complete a two year study to identify why we are lagging behind in productivity compared to our competitors. They drew four conclusions. The first one was education. The input into our factory is so poor it is no wonder the output is so bad. It is education. Certainly they do not push the problem onto your shoulders. We are part of the educational system and should take a major role to shape up this situation. Education indeed is the major thing that is now hurting us. Before we can talk about the automation of the future we have to get the human input factor into the right shape.

CLOSING COMMENTS

Scott D. Johnson

Franzie Loepp organized his talk around the three R's and I am going to summarize my observations, the things I got out of this meeting, around the four R's. The first R was a *reinforcement* of the workforce reports. The things we heard from the presenters just reinforced what these people have been saying. We do need broader skills; the communication skills, academic skills and interpersonal skills. We do need more math and science. We heard that from several different presenters.

We have the global corporation that Steven Lu was talking about. What are the implications for that? As we send the labor force to a different country, we may have to keep the brain force for that corporation here in this country. What are the ramifications of that?

We heard a lot about the team concept. We heard about coordination, collaboration, and cooperation. Our students will need that. Flexibility, maneuverability... As Steven Lu said, the most valuable worker will be the one that is able to deal with crisis. That is the problem solver, the critical thinker.

The second R most of you have been able to capture in the course of your discussions, that's *restructuring*. It seems to me that all of education is vocational education. Someone even said that earlier. Math, science and the types of courses that we typically deal with in vocational education, they all have a vocational aspect to them as long as you define that very broadly. We also look at vocational education as much more than 11th and 12th grade skill courses. There are a lot of opportunities for vocational education at the secondary level. Community colleges are dealing with vocational education even though they don't care to use that term. The private sector is involved in vocational education and they don't use that term either. Whatever the term means, they are doing similar things.

The American Vocational Association has not been a real good ally in fostering this broad view of vocational education. They have focused on the upper secondary level. If you talk with people in a post secondary organization like the National Coalition of Advanced Technology Centers, they feel like the American Vocational Association has turned their backs on them. But, they are doing the same types of things and they need to work together.

In this restructuring we need more emphasis on process, maybe less on content. Was it you Alan, who said, "When you get out of school the content will be completely different." One of the problems we are faced with is our testing system. We have got to justify our learning gains with ACT test scores. If we teach process it may have a long term implication, but how can we show that students have improved in problem solving and critical thinking, those important process skills? Luckily the testing services are interested in this and have a task force working on trying to assess thinking abilities. That is something that is going to be very important for us to deal with.

Another issue that came out when dealing with restructuring was science and technology aren't separate entities. There is a continuum there. Rita Fischbach made a comment yesterday that maybe engineering is at the center of that continuum. It brings science and technology together. If those two are on a continuum, we need to begin breaking down the disciplinary structures in our schools. We cannot have a science teacher teaching in isolation, a technology teacher in isolation, they need to work together.

A final point in the restructuring is the core curriculum. Dan Hull spent quite a bit of time talking about that. That is this notion of providing a foundation upon which a more specific occupational training will be provided.

Tim Wentling and I were talking a little bit earlier about Tech Prep. There could be a lot of money from the federal government to support Tech Prep programs. Tim was commenting on the fact that there is a lot of misinterpretation of what Tech Prep is. Most people are viewing it as technical preparation. If you view it as technical preparation then you have skill specific courses that lead up to more skill specific courses. I don't think that's the essence of the Tech Prep program. Tim has been doing a lot of study in Indiana of some very good Tech Prep programs, and believes that maybe it's not technical preparation, but technological preparation or technological literacy preparation. It is something much broader. Something that provides the foundation on which that post secondary or occupational program can build.

Now, the third R is *responsibility*. It seems that when we deal with the important advanced technologies, they are kind of sexy areas. They get people excited. A couple of years ago Norton Grubb wrote a paper that dealt with people jumping on the high tech bandwagon. We have a lot of community college programs that are building these advance technology centers. They are starting up these new programs. They are basing those new programs on occupational data that says this area is growing tremendously. We have a 90% increase in the number of jobs. The problem is, at a national level you are looking at maybe 30,000 jobs all together. The percentage increase is not the right way to look at that. If you look at actual numbers of workers, you can see that you won't have every community college develop this high tech program. It is our responsibility to develop these programs based on a thorough needs assessment and not just jump on the bandwagon.

Another responsibility area is dealing with society. What are we going to do with this bottom 25% or bottom 50%? Most of the topics that we dealt with focused on the best and brightest students. We have a responsibility to deal with the disadvantaged, the special needs, the minorities, and the dropouts. Those are all issues that vocational education traditionally has played a big part in. We need to continue to do that. We certainly cannot turn our backs on those people.

The fourth R is reports. No, we don't need more reports, but I do want you to know that we have recorded the whole symposium. We will be transcribing these tapes and putting a publication together. All of you who were participants here will receive a copy of that. That will be our report of the symposium.

Based on the comments I have gotten I think this has been very successful. There is a lot of information. I am looking forward to reading through the talks that were given.

Rupert N. Evans

I have enjoyed today's presentations very much. It is always interesting to me to attend one of these symposia. I always learn a lot. One of the things that is most interesting, is to see how things change over time. You know when I started in vocational education all we talked about was secondary schools and a little bit about adult education.

Did you know, at one time offering adult education to an unemployed person was illegal? Do you know the reason for that? There were a lot of people who were afraid that vocational education would be used to train strike breakers. As a result, you had to have job before you could enroll in vocational education courses. Further, the course had to be related to your employment. That didn't change until 1963. It was not until 1968 that a graduate of a vocational education program went on to any kind of higher education. That was a black mark against the program. 1968 was not all that long ago. The goal of vocational education at that time was to turn out people who would go to work immediately upon graduation from a secondary school. It took us a long time to recognize that these people had a very important role to play. We did not start spending substantial money for vocational education until 1968. There have been lots of changes.

At almost every one of these symposiums I hear people talking about preparing people to meet employers needs. This causes me to wince. I'd feel a lot more comfortable if we would talk about meeting the needs of society for technical workers, or skilled workers, not employer's needs. I kind of like Joe Hill's ability to be able to move from one job to another. Job mobility is a fascinating thing. It is a very important thing. It's a thing that should be promoted above all else. If one has mobility, then one has a chance to bargain over working conditions. If you don't have that, you are trapped.

I'm a little bit bothered by an almost implicit assumption that we do not want to touch the bottom 25% of the people in high schools. I noticed that a couple of you, in your comments, recognized that. I was glad to hear you pick up on it. Are you aware that the high school dropout rate has increased again this last year? We are now failing to graduate 29% of our high school students. That number has been growing steadily over the past 15 years. The person who is most disadvantaged in the workforce today is not the minority or female, but the person who does not have a standard high school diploma. Anybody who thinks that the GED replaces the standard high school diploma doesn't know the armed forces or the number of employers who silently, and sometimes not so silently discriminate against GED holders. If vocational education has a job to do in helping students, it is keeping those students in high school. I don't care whether you're giving them technical skills or not. Yes I do. Of course I want you to impart technical skills. If you can persuade them to complete high school, you will be doing the single most important thing in terms of giving them an advantaged in the job market. Let's make that a vocational education goal.

I almost thought that I heard that we don't want to train people unless we are going through a down cycle. If we train people too much then they may leave and go to work for a competitor. One way to hold on to people is not to train them too much. That is surely not what we want to do in vocational technical education. We want to increase job mobility.

I wish you success in your group discussions.

Thank you.

PRESENTER BIOGRAPHIES

Dr. Alan L. McClelland, Deputy Director
Teacher Preparation and Enhancement
Science and Engineering Education Directorate
National Science Foundation

Dr. McClelland was appointed to the National Science Foundation in 1987 after 30 years of service with E. I. DuPont De Nemours & Company in Wilmington, Delaware. During that period, he held a wide range of positions including Assistant to the Vice President of Research and Development, Administrator and Manager of Personnel, Special Recruiting and Employee Relations, College Relations Representative, and Member of the Research Staff. Prior to that time, he served as Vice President of Engineering for the Cherry Burrell Corporation, taught in the Department of Chemistry at the University of Connecticut, and severed as an Assistant Engineering Officer in the United States Navy. His service in volunteer and professional organizations includes numerous national offices in the American Chemical Society and he is a founding member of the Triangle Coalition for the Improvement of Precollege Science and Technology Education.

Dr. Franzie L. Loepp
Department of Industrial Technology
Illinois State University

Dr. Loepp is a Distinguished Professor in the Industrial Technology Department at Illinois State University in Normal, Illinois. He has had a major impact on the evolution of technology education in the state and nationally through his curriculum development work; particularly one multiyear effort that resulted in the development of the Illinois Plan for Industrial Education. Dr. Loepp has authored numerous articles, conference proceedings, and book chapters and has presented papers at many professional meetings. He was recently awarded the Rutherford E. Lockette Humanitarian Award from the International Technology Education Association and has received numerous other awards and recognitions including Industrial Arts Teacher of the Year, Outstanding Young Technology Teacher, and an Outstanding Research Award.

Mr. Daniel M. Hull
President
Center for Occupational Research and Development

Mr. Hull is a registered electrical engineer with 14 years industrial experience in lasers, telecommunications, space technology and radar systems before joining CORD in 1974. For the past 16 years, he has developed, managed and directed research, curriculum design, instructional materials development, and consulting services for technical and vocational education throughout the United States and internationally. He has published over thirty papers and delivers more that forty presentations annually on innovative topics in technical education and economic development.

Mr. Joe Hill
Senior Training Consultant
AT&T Corporate Education and Training

Mr. Hill is a Senior Training Consultant for AT&T Corporate Education and Training in Chicago, Illinois. Mr. Hill is responsible for the formulation and implementation of training curriculums for several thousand managers across the Central United States. He frequently consults with clients regarding appropriate courses and programs that are required to ensure that the overall corporate needs of AT&T are addressed and accomplished. Prior to working for AT&T, Mr. Hill has been an elementary school teacher and principal in the Chicago and St. Louis Public School systems. He continues to teach weekly adult classes with the Johnnie Colemon Institute in Chicago, Illinois.

Dr. Stephen Lu
College of Engineering
University of Illinois

Dr. Lu received his M.S. and Ph.D. degrees in Mechanical Engineering from Carnegie-Mellon University. He is now a tenured Associate Professor, and funding Director of the Knowledge-Based Engineering Systems Research Laboratory at the Mechanical and Industrial Engineering Department at the University of Illinois at Urbana-Champaign. His research interests are in the development of artificial intelligence based techniques for advanced engineering automation, and the integration of these techniques with traditional engineering methods. Currently, he is developing the knowledge processing technology to support various concurrent product development and system management activities. He has published over 70 technical papers, reports, and book chapters in this area, and served as a keynote speaker for several national and international conferences. Dr. Lu received the Presidential Young Investigator Award from the National Science Foundation in 1987, the Outstanding Young Manufacturing Engineer Award from the Society of Manufacturing Engineers in 1988, and the Xerox Senior Faculty Research Award from UIUC for high quality research over the last five years.

AGENDA

Advanced Technology and the Workforce: An Evolving Agenda for Instructor Preparation

11th ANNUAL
RUPERT N. EVANS SYMPOSIUM ON VOCATIONAL EDUCATION
Allerton House, Monticello

May 3-4, 1990

Thursday, May 3

8:30 Coffee and Registration

9:00 Symposium Overview
 Dr. Scott D. Johnson, Symposium Chair
Welcome
 Dr. David Pearson, Dean
 College of Education

9:30 Presentation: *The Changing Workforce*
Presenter: Dr. Alan L. McClelland, Deputy Director
 Teacher Preparation and Enhancement
 Science and Engineering Education Directorate
 National Science Foundation

Moderator: Scott D. Johnson, University of Illinois

10:45 Break

11:00 Presentation: *The Changing Workforce: Implications for Secondary School Programs*
Presenter: Dr. Franzie L. Loepp
 Department of Industrial Technology
 Illinois State University

Moderator: Brian McAlister, University of Illinois

12:00 Lunch

1:30 Presentation: *The Changing Workforce: Implications for Community College Programs*
Presenter: Mr. Daniel M. Hull, President
Center for Occupational Research and Development

Moderator: Chris Roegge, University of Illinois

2:30 Break

2:45 Presentation: *The Changing Workforce: Implications for Private Sector Training Programs*
Presenter: Mr. Joe Hill
Senior Training Consultant
AT&T Corporate Education and Training

Moderator: Deborah Bragg, University of Illinois

3:45 Small Group Work Sessions

5:00 Social Hour

5:45 Dinner

Friday, May 4

7:30 Breakfast

8:30 Reports from Small Groups

9:00 Presentation: *Projections for the Factory of the Future*
Presenter: Dr. Stephen Lu
College of Engineering, University of Illinois

Moderator: Scott D. Johnson, University of Illinois

10:00 Break

10:15 Small Group Work Session

11:45 Final Group Reports, Discussion, and Closing Comments
Scott D. Johnson, Symposium Chair

12:30 Depart from Allerton

PARTICIPANT LIST

Deborah D. Bragg
University Of Illinois
344 Education Building
1310 South Sixth Street
Champaign, IL 61820

Brenda Erickson
RR#1 Box 369a
Carbondale, IL 62901

John Andrew Evans
University Of Illinois
349 Education Building
1310 South Sixth Street
Champaign, IL 61820

Rupert N. Evans
1842 Maynard Dr.
Champaign, IL 61820

Rita Fischbach
University Of Illinois
42 Education Building
1310 South Sixth Street
Champaign, IL 61820

Brendan Foley
University Of Illinois
345 Education Building
1310 South Sixth Street
Champaign, IL 61820

Charles Gordon
University Of Illinois
345 Education Building
1310 South Sixth Street
Champaign, IL 61820

Mildred Griggs
University Of Illinois
352 Education Building
1310 South Sixth Street
Champaign, IL 61820

Darla Haines
University Of Illinois
42 Education Building
1310 South Sixth Street
Champaign, IL 61820

Deborah Halvna
University Of Illinois
42 Education Building
1310 South Sixth Street
Champaign, IL 61820

Joe Hill
Senior Training Consultant
AT&T Corp. Ed. & Training
Chicago, IL

Richard K. Hofstrand
School of Technology
Eastern Illinois University
Charleston, IL 61920

Glenda Huffman
University Of Illinois
349 Education Building
1310 South Sixth Street
Champaign, IL 61820

Scott D. Johnson
University Of Illinois
350 Education Building
1310 South Sixth Street
Champaign, IL 61820

George F. Kreider
Kankakee Comm. College
River Road - Box 888
Kankakee, IL 60601

Carolyn Lawson
University Of Illinois
353 Education Building
1310 South Sixth Street
Champaign, IL 61820

Franzie L. Loepp
Dept. of Industrial Technology
Illinois State University
Normal, IL 61761

Brian McAlister
University Of Illinois
342 Education Building
1310 South Sixth Street
Champaign, IL 61820

Sandy Mercer
ISBE/DAVTE
100 North First Street
Springfield, IL 62777-0001

Daniel M. Hull, President
CORD
601 C Lake Air Drive
Waco, TX 76710

H.C. Kazanas
University Of Illinois
348 Education Building
1310 South Sixth Street
Champaign, IL 61820

Linda Lafferty
ISBE/DAVTE
100 North First Street
Springfield, IL 62777-0001

Jim Leach
University Of Illinois
356 Education Building
1310 South Sixth Street
Champaign, IL 61820

Stephen Lu
University Of Illinois
College Of Engineering
142 Mech. Engr. Building
Urbana, IL 61801

Alan L. McClelland
Deputy Director
Directorate for Science & Eng. Ed.
National Science Foundation
Washington, DC 20550

Robert Nelson
University Of Illinois
346 Education Building
1310 South Sixth Street
Champaign, IL 61820

Frank O'Connor
University Of Illinois
353 Education Building
1310 South Sixth Street
Champaign, IL 61820

E. Kenton Peak
Ill Eastern Comm Coll
233 East Chestnut St
Olney, IL 62450

Elizabeth Platt
University Of Illinois
343 Education Building
1310 South Sixth Street
Champaign, IL 61820

Chris Roegge
University Of Illinois
355 Education Building
1310 South Sixth Street
Champaign, IL 61820

Gene Roth
Office for Voc. Tech. & Career Ed.
Northern Illinois University
DeKalb, IL 60115

Sally Steffens
University Of Illinois
42 Education Building
1310 South Sixth Street
Champaign, IL 61820

Joe Talkington
Illinois State University
Dept. of Ind. Technology
Normal, IL 61761

Pat Patsloff
Southern Illinois University
Edwardsville Campus
Edwardsville, IL

Ethel Pichon
Inst. Materials Coor.
Ed. Service Center #13
200 S. Fredrick St.
Rantoul, IL 61866

Richard Polanin
Illinois Central College
TK8
East Peoria, IL 61635

Doug Rokke
University Of Illinois
42 Education Building
1310 South Sixth Street
Champaign, IL 61820

Jack Shrawder
University Of Illinois
345 Education Building
1310 South Sixth Street
Champaign, IL 61820

Wendall Swanson
Western Illinois University
College Of Aptlied Science
215 Knoblauch Hall
Macomb, IL 61455

Alison Vincent
University Of Illinois
42 Education Building
1310 South Sixth Street
Champaign, IL 61820

Judy Warthen
Curriculum Revitalization
Western Illinois University
Macomb, IL 61455

John Washburn
Univ Occup. Ed Coordinator
Southern Illinois University
Carbondale, IL 62901

Mary Waters
Western Illinois University
Macomb, IL 61455

Tim Wentling
University Of Illinois
357 Education Building
1310 South Sixth Street
Champaign, IL 61820

Marsha Woodbury
University Of Illinois
42 Education Building
1310 South Sixth Street
Champaign, IL 61820

Brenda Yates
Egyptian Ed. Service Center
1006 D. North Carbon St
Marion, IL 62958

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Thomas Lay Burroughs, Chairman
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July, 1990

Final Report of the Sophisticated Technologies Project

Illinois State Board of Education

Adult, Vocational and Technical Education

FINAL REPORT ABSTRACT

Official Project Title: A Conceptualization Of Sophisticated Technologies And An Identification Of Vocational Education's Role In Preparing Students With The Competencies Needed To Work With Those Sophisticated Technologies.

Department of Adult, Vocational and Technical Education Funding Agreement #OKAC19D

Project Director: Scott D. Johnson, Assistant Professor, University of Illinois

Funded Agency: Department of Vocational & Technical Education

Location of Funded Agency: University of Illinois at Urbana-Champaign

Time Period Covered: July 1, 1989 - July 31, 1990

Goals of the Project and its Relevancy to Vocational Education: This project completed two major activities related to the impact of advanced technologies on the workforce and on vocational education. First, the project made Illinois vocational educators aware of the impact of advanced technology on the workforce and on vocational education by sponsoring a symposium. Second, the project engaged in an ethnographic study of existing vocational curriculum and instruction to determine if they lead to the development of the competencies needed by workers of the future.

Major Accomplishments of the Project: This project has resulted in:

1. a published set of proceedings from the symposium on the impact of advanced technology and the workforce.
2. a set of research findings which documents current instructional practice in advanced technology programs in Illinois community colleges.

These accomplishments will provide guidance to DAVTE as future programs, curriculum development, and inservice activities are planned. These accomplishments will also affect current vocational programs in the State of Illinois through the future implementation of content and instruction which develops the knowledge, skills, and attitudes that students will need to work with sophisticated technologies.

Products Delivered:

Title: Current Practice in Preparing the Future Workforce: An Analysis of Advanced Technology Programs in Illinois Community Colleges
Type: Research Report
Quantity: 10 (300 copies printed)
Recipients: DAVTE; Career Deans at Illinois Community Colleges (Also available upon request)
Delivery: July 31, 1990

Title: Advanced Technology and the Workforce: An Evolving Agenda for Instructor Preparation
Type: Conference Proceedings
Quantity: 10 (300 printed)
Recipients: DAVTE; Career Deans at Illinois Community Colleges (Also available upon request)
Delivery: July 31, 1990

Expenditure of Funds:

While the final balance will be determined by University of Illinois Grants and Contracts, no discrepancies are expected between the funding agreement and the actual expenditures reported. In fact, the actual expenditures are less than the funded amount.

Paid Participants in Activity:

Scott D. Johnson, Project Director
Assistant Professor
Department of Vocational and Technical Education
University of Illinois at Urbana-Champaign

Dr. Johnson has been involved in vocational education for 13 years as an instructor at the secondary school level, a program developer and instructor in industry, and as a teacher educator at the post-secondary level. He has been involved in curriculum development projects at the district and state levels and has conducted research to identify the differences between expert and novice workers on technical tasks and to develop instructional strategies to more effectively bring the novice to the level of the expert.

W. Tad Foster, Research Assistant
Department of Vocational and Technical Education
University of Illinois at Urbana-Champaign

Mr. Foster was a doctoral student in the Department of Vocational and Technical Education at the University of Illinois at Urbana-Champaign and is now employed at Purdue University. He has extensive experience as an instructor in technical areas. His research interests include the impact of technology on the workforce and education.

John A. Evans, Research Assistant
Department of Vocational and Technical Education
University of Illinois at Urbana-Champaign

Mr. Evans is currently a doctoral student in the Department of Educational Psychology at the University of Illinois at Urbana-Champaign. He has experience as an instructor in the public schools education and has expertise in statistical data analysis.

James Galloway, Research Associate

Mr. Galloway is a former Assistant Superintendent for the Illinois State Board of Education. He has special expertise, experience, and contacts in the Illinois vocational education community.

Resource Listing:

Material Resources:

Numerous research reports and materials were obtained during this year of the project are are available from the Project Staff.

Human Resources:

A number of individuals were involved in this project either as a respondent to a survey, through interviews, or through observation of their instruction. Because much of the data collection was confidential, only the numbers of participants can be identified. The following list details the people involved in the data collection activities:

1. A total of 240 advanced technology instructors at Illinois community colleges completed questionnaires.
2. A total of 21 advanced technology programs in the State of Illinois were identified for site visits. From these programs, a total of 57 individual courses were randomly selected. Of these courses, 9 were primarily academic-oriented courses and 48 were primarily technical in nature.
3. A total of 82 individuals were selected to be interviewed. Of these 82 individuals, 27 were administrators and 55 were instructors. The 27 administrators selected for interviews had job classifications of either career dean or department head. A total of

six career deans and 21 department heads were eventually interviewed. The instructors who were selected for interviews were classified as instructors in the areas of biological technology (16), informational technology (21), physical technology (11), and academics (7).

The following individuals participated and/or presented at the Evans Symposium:

Debra D. Bragg
John Andrew Evans
Rita Fischbach
Charles Gordon
Darla Haines
Joe Hill
Glenda Huffman
Scott D. Johnson
George F Kreider
Carolyn Lawson
Franzie L. Loepp
Brian McAlister
Sandy Mercer
Frank O'Conner
E Kenton Peak
Elizabeth Platt
Chris Roegge
Gene Roth
Sally Steffens
Joe Talkington
Judy Warthen
Marsha Woodbury

Brenda Erickson
Rupert Evans
Brendan Foley
Mildred Griggs
Deborah Halvna
Richard K. Hofstrand
Daniel M. Hull
H.C. Kazanas
Linda Lafferty
Jim Leach
Stephen Lu
Alan L. McClelland
Robert Nelson
Pat Patsloff
Ethel Pinchon
Richard Polanin
Doug Rokke
Jack Shrawder
Wendall Swanson
Alison Vincent
Tim Wentling
Brenda Yates

Major Accomplishments and Significant Findings:
Project Objectives:

Objective 1. By September 15, 1989, develop the methodology for conducting the ethnographic study of vocational programs through consultation with experts in evaluation, qualitative research methods, curriculum development, and teacher effectiveness research.

Objective 2. By January 31, 1989, conduct an intensive ethnographic study of post-secondary vocational programs in Illinois. This study will review existing vocational curriculum documents and will observe the instructional strategies used by vocational instructors to determine their effectiveness in developing the competencies needed to work with sophisticated technologies.

The ethnographic study of post-secondary vocational programs was completed. This study involved the collection of survey, interview, and observation data and resulted in a technical report which documented the research procedures and the study findings.

Objective 3. By December 31, 1989, determine the format, schedule, and desired topics for the symposium entitled "The Impact of Technology on the Workforce and Vocational Education." Symposium speakers will be contacted and provided with guidelines regarding their expected contribution. Publicity for the symposium will also be completed by this time.

Objective 4. By March 31, 1990, obtain and complete the editing of the symposium proceedings.

Objective 5. By April 30, 1990, hold the symposium entitled "The Impact of Technology on the Workforce and Vocational Education."

The symposium was held on May 3 and 4 at Allerton House near Monticello, Illinois. Nearly fifty participants attended the symposium to hear presentations from a variety of speakers. The participants also discussed the issues raised at the symposium in small group activities.

Objective 6. By May 31, 1990, design an inservice activity which will help vocational educators revise their curriculum and instruction to more effectively help student gain the competencies needed to work with sophisticated technologies. The design of the inservice activity will be based on Year 1 project data, on the results of the ethnographic study conducted in the fall of 1989, and on the presentations made during the symposium.

Based on the data collected through the ethnographic study and from discussions with various individuals around the state, it was decided that the development of inservice activities for community college instructors would not be as effective as originally thought. As a result, a different approach to professional development of community college faculty was selected and written into the FY91 project proposal.

Objective 7. By June 30, 1990, complete and submit the symposium proceedings, the inservice activity plan, and the final project report.

Objective 8. By October 15, January 15, April 15, and July 31, disseminate project progress/results to DAVTE.

All progress reports have been written and submitted according to the project timelines. Project projects are currently at the printer and will be submitted the DAVTE as soon as possible.

Major Dissemination Activities Summary:

The data collected by the project staff before February 15th was presented at the IVA Convention in Itasca, Illinois. Tad Foster presented the conceptual definitions and classification scheme, discussed the impact of technology on the workforce as it related to the changing nature of skill requirements and job availability, and suggested what impacts might occur for vocational education in the future. He also discussed the purpose and process of the ethnographic study in instruction in community colleges.

The symposium proceedings and the research report document will be mailed to the career deans at each community college. In addition, those documents will be disseminated to publication clearinghouses by DAVTE representatives. Copies of the documents will also be available by request.

Staff Development:

No special staff development activities were planned nor carried out.

Publicity:

No publicity for the project was sought other than that obtained through project correspondence and interviews.

Problems:

As work progressed through the year, it became apparent that the project timeline needed to change. The amount of time to collect the site data was underestimated and mid-year staff changes forced the project to fall behind in its schedule. However, with the appointment of Galloway and Evans for the Project Staff, the objectives of the project were reached within the expected time frame. These difficulties were discussed with the project contract administrator, Jerry Ohare, and we are confident that the original intent of the RFP has been met.

Summation of Evaluation Data:

Overall, the project was able to reach its objectives. Based on the evaluation data collected during the project activities, several minor changes in the project direction were identified and implemented.

Statement of Impact:

This project has resulted in an increased awareness of the impact of sophisticated technologies on the workforce and on vocational education and as greater understanding of the effectiveness of current vocational curriculum and instruction in developing the competencies needed to successfully work with sophisticated technologies.

These results should provide guidance to DAVTE as future programs and curriculum development activities are planned. These results should also impact the effectiveness of current vocational programs in the State of Illinois through the future implementation of content and instruction which develops the knowledge, skills, and attitudes that students will need to work with sophisticated technologies.

Conclusions and Recommendations:

Based on the findings of this project, it is recommended that the following points be addressed by future projects and activities:

1. Integration of academic and vocational content does not seem to be occurring. Administrators need to ensure that the advanced technology programs give explicit attention to academic content and that the instructors provide adequate emphasis to that component of the curriculum.
2. Students appear to be entering the advanced technology programs with low levels of basic skills. Secondary schools must ensure that their graduates have actually obtained the knowledge and skills needed to succeed in the community college programs.
3. Very little instructional time is spent enhancing student's basic skills. Strategies for enhancing the integration of academic and vocational/technical content need to be developed and tested.
4. Students spend minimal time working in groups. Professional development activities need to be planned so instructors can develop the skills needed to effectively organize and manage cooperative learning and small group instruction.
5. The lack of minority instructors and students should be a major concern.
6. Finding qualified instructors in some areas is difficult. The instructional areas that lack qualified instructors need to be identified and strategies for filling the vacant positions need to be developed.
7. Many instructors lack recent work experience in their teaching area. Administrative support and encouragement for "technically-oriented" professional development activities must be provided.
8. A high percentage of the advanced technology instructors report that they do not receive student follow-up data. Better dissemination of the student follow-up data is needed.
9. Lack of room for facility and program expansion. Study of the potential for program growth and the need for facility expansion may be needed in the near future.
10. Funding support for advanced technology programs is limited. An awareness of the current limitations and the potential for future problems is needed to prevent these state-of-the-art programs from becoming outdated.

Product Abstracts: (On following pages)

ILLINOIS STATE BOARD OF EDUCATION
DEPARTMENT OF ADULT, VOCATIONAL AND TECHNICAL EDUCATION
VOCATIONAL EDUCATION PROGRAM IMPROVEMENT SECTION

PRODUCT ABSTRACT

1. Title of material Current Practice in Preparing the Future Workforce: An Analysis of Advanced Technology Programs
2. Date material was completed July, 1990
3. Please check those applicable: New material XX Revised material ____ Field-tested material ____
4. Originating agency Department of Vocational & Technical Education

   Address 1310 So. Sixth St, Champaign, IL Zip Code 61820
5. Name(s) of developer(s) Scott D. Johnson

   Address 1310 So. Sixth St. Champaign, IL Zip Code 61820
6. Developed pursuant to Contract Number OKAC19D
7. Subject Matter (Check only one according to Dept. of Education Code):

   Code
   - __ 01 Agricultural Education
   - __ 03 Bus., Mrktng. & Man. Occup.
   - __ 04 Distributive Education
   - __ 07 Health Occupations Education
   - __ 09 Home Economics Education
   - __ 10 Industrial Technology
   - __ 16 Technical Education
   - __ 17 Trade & Industrial Educ.
   - __ 22 Cooperative Education
   - __ Career Education
   - XX Other (Specify) Voc. Ed.
8. Education Level
   - ____ Pre-K Thru 6
   - ____ 7-8
   - ____ 9-10
   - ____ 11-12
   - ____ Post-Secondary
   - ____ Adult
   - XX Tchr. (Inservice)
   - XX Adm. (Pre Service)
   - ____ Other (Specify) ____
9. Intended for Use By:
   - ____ Student
   - ____ Classroom Teacher
   - XX Local Administrator
   - XX Teacher Ed.
   - XX Guidance Staff
   - XX State Personnel
   - ____ Other (Specify) ____
10. Student Type:
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Address 350 Education Building Zip Code 61820

1310 So. Sixth Street, Champaign, IL

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Contact: Illinois State Board of Education
Department of Adult, Vocational & Technical Education
Vocational Educ. Program Improvement Section, E-426
100 North First Street
Springfield, Illinois 62777-0001
(217) 782-4620

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17. Person Completing this Abstract Scott D. Johnson
Full Address
350 Education Building
1310 So. Sixth Street
Champaign, IL 61820

EXECUTIVE SUMMARY

Current trends in vocational and technical education provide convincing evidence that the traditional curriculum may not equip students with the skills necessary to work with sophisticated technologies. The knowledge base of technology has changed in recent years. New technologies require different types of knowledge to be taught in vocational education. Similarly, technological advances require future workers to possess new technical skills. Vocational education's traditional emphasis on specific job skills may not be the most effective and efficient method of preparing future workers. Because of rapid and complex changes in technological knowledge and skill, the specific technical job skills taught in many vocational programs are obsolete when vocational graduates enter the workforce. Hence, specific technical job skills are no longer a sufficient condition for employment. The emerging instructional trend is toward an increased emphasis on thinking processes and generalizable skills. By helping students gain these generic skills along with basic technical skills, graduates of vocational programs will possess the "transferable" skills needed to keep up with the rapid technical changes in the workplace.

In an effort to better understand the impact of advanced technologies on the workforce, the Illinois State Board of Education, Department of Adult, Vocational and Technical Education, funded a project to consider the nature of "sophisticated technologies" and to determine the knowledge and skill requirements for occupations in these sophisticated technology areas. The primary activities of this project were to examine relevant literature, analyze the recommendations of the major workforce projection documents that have appeared in recent years, and interview business and industry representatives to determine their perceptions of the competencies needed by the workforce of the future. Data collected during numerous interviews with management level personnel clearly suggests that the major competencies desired by business and industry include both specific technical skills and general basic skills. Johnson, Foster, and Satchwell (1989) concluded from this data that individuals will need to possess a wide variety of "transferable skills" in addition to technical competencies to succeed in future "high technology" occupations.

While it is difficult to identify the impact of technology on the specific technical skills needed by the workforce, it appears that the private sector has accepted the fact that individuals who possess the desired technical skills are scarce. As such, businesses and industries are hiring the most trainable individuals. These individuals are then provided with the necessary technical skills through in-house training or through external training arrangements. Because of this trend in hiring trainable individuals, the most desired competencies are now the general basic skills that enhance an individual's learning ability (Carnevale, Gainer, & Meltzer, 1988; Carnevale & Schulz, 1988; Johnson, Foster, & Satchwell, 1989; Johnston & Packer, 1987; McLaughlin, Bennett, & Verity, 1988).

The impact of these broad competencies on vocational education should be readily apparent. Vocational education cannot emphasize only the development of technical skills in the curriculum, rather a quality vocational program that prepares students with the types of competencies indispensable to business and industry must include instruction and learning experiences that develops the basic competencies.

The purpose of this study was to examine post-secondary vocational curricula that has integrated sophisticated technology content into existing curricula to determine if the competencies most required by business and industry are adequately addressed in the curriculum. The three objectives used to operationalize the study were:

1. To determine the extent to which advanced technology curricula at the community college level provides for the development of the competencies needed for successful employment in sophisticated technology occupations.

2. To determine the extent to which instructional methods and materials used in advanced technology curricula at the community college level provide the competencies needed for successful employment in advanced technology occupations.
3. To determine the extent to which the facilities, equipment, staffing, and funding support the effective delivery of advanced technology curricula at the community college level.

A variety of data collection techniques were used to achieve the project objectives. First, a survey of the the instructors of advanced technology programs was completed to collect information about the demographics and perceptions of the advanced technology instructors, the site observations and interviews were designed to determine what is actually happening in the community college programs. Second, career deans and department heads were interviewed. The administrator interviews focused on the quality of the programs and management issues while the instructor interviews focused on curriculum and instruction. Third, while the surveys and interviews provided demographic information about the advanced technology instructors and their programs and brought out individual perceptions on a variety of issues they could not identify what was actually happening in the classroom once the door was shut and instruction began. In order to gain an understanding of actual instructional practice in the advanced technology programs, on-site observations were completed. These observations were conducted in a variety of classes and focused on what was taught, how it was taught, who was involved as instructors and learners, and the environmental setting in which the instruction took place. These multiple sources of data collected through the survey, interviews, and observations allowed triangulation of the data to increase the reliability and validity of the study and to provide a trenchant interpretation.

Through this study and the subsequent data analysis, many strengths in the advanced technology programs became apparent. Those strengths are identified below.

Strengths of the Advanced Technology Programs

1. Instructors in advanced technology programs rank the enhancement of students' thinking skills highest on their list of educational goals.
2. Considerable instructional time is devoted to the enhancement of student's thinking skills. In over 80% of the instructional episodes observed during the site visits students were involved in activities that emphasized higher order thinking skills.
3. Instructors of advanced technology programs rank to the goal of improving students' basic academic skills fairly high.
4. Instructors recognize that strong academic skills are an essential requirement for the worker of the future.
5. A considerable amount of the advanced technology instructors' time is spent on things directly related to teaching. These instructors use a majority of their time either preparing to teach or actually teaching.
6. Business, industry, and labor constituencies have considerable influence in the development of advanced technology curricula.
7. Instructors of advanced technology programs are extremely well educated. Ninety-one percent of the instructors have at least a baccalaureate degree, 79% have masters level degrees, and over 6% of the instructors have earned doctorates.
8. There appears to be little difficulty finding qualified instructors in many advanced technology program areas.
9. Both the administrators and the instructors view the faculty as a major strength of the advanced technology programs.
10. The equipment used in the advanced technology program is generally up-to-date and is viewed as a strength of the programs.
11. The majority of the students in the advanced technology programs are highly motivated. It was reported that high motivation was particularly prevalent in the older students.

The findings of this study suggest that the advanced technology programs do address many of the competencies needed by the worker of the future. However, numerous problems related to the advanced technology programs also became evident. The problem areas that surfaced during this study are identified below along with suggestions for resolving those problems.

Problem Areas Related to the Advanced Technology Programs

1. Integration of academic and vocational content does not seem to be occurring.
2. Students appear to be entering the advanced technology programs with low levels of basic skills.
3. Very little instructional time is spent enhancing student's basic skills.
4. Students spend minimal time working in groups.
5. The lack of minority instructors and students should be a major concern.
6. Finding qualified instructors in some areas is difficult.
7. Many instructors lack recent work experience in their teaching area.
8. A high percentage of the advanced technology instructors report that they do not receive student follow-up data.
9. Lack of room for facility and program expansion.
10. Funding support for advanced technology programs is limited.
11. Identifying community college instructors for research purposes is a difficult process.

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PRODUCT ABSTRACT

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   Address 1310 So. Sixth Street, Champaign, IL Zip Code 61820
5. Name(s) of developer(s) Scott D. Johnson

   Address 1310 So. Sixth Street, Champaign, IL Zip Code 61820
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   _ 16 Technical Education
   _ 17 Trade & Industrial Educ.
   _ 22 Cooperative Education
   Career Education
   XXX Other (Specify) Voc. Ed.
8. Education Level

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   ___ Post-Secondary ___ Adult XXX Tchr. (Inservice)
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Vocational Educ. Program Improvement Section, E-426
100 North First Street
Springfield, Illinois 62777-0001
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17. Person Completing this Abstract Scott D. Johnson
Full Address
350 Education Building
1310 So. Sixth Street
Champaign, IL 61820

This document contains the proceedings from the 11th Annual Rupert N. Evans Symposium which was held on May 3-4, 1990 at Allerton House near Monticello, Illinois. The agenda for the symposium evolved through the work of the Sophisticated Technologies project which is funded through DAVTE/ISBE and housed at the University of Illinois. Prior work on that project identified the need to provide future workers with the generalizable knowledge and skills needed to successfully work in and adapt to the ever changing technological workplace. However, in order to provide future workers with these broad competencies, different ways of teaching may also be needed. This symposium was planned to address the issue of preparing instructors who are able to provide appropriate educational opportunities that foster the development of the competencies needed for gainful employment. The title of the symposium was *Advanced Technology and the Workforce: An Evolving Agenda for Instructor Preparation.* Over 45 vocational educators attended the symposium to hear presentations and discuss the implications of the changing workforce on the preparation of instructors for secondary schools, community colleges, and private sector training programs. Five distinguished speakers presented their views on the changing nature of the workplace as a result of advances in technology and what those changes mean for the preparation of instructors. Dr. Alan McClelland from the National Science Foundation provided a broad view of the changing nature of the workplace and describe some of the challenges that face both education and business/industry. Dr. Franzie Loepp from Illinois State University discussed the competencies that will be needed by secondary instructors who provide students with broad exposures to technology and its implications. Mr. Daniel Hull from the Center for Occupational Research and Development presented the community college perspective and stressed the importance of providing breadth in technical instruction prior to in-depth technical training. Mr. Joe Hill from AT&T's Corporate Education and Training Center describe some of the current efforts by the private sector to prepare their workforce for the changing technologies. The final presenter was Dr. Steven Lu from the University of Illinois who provided a futuristic view of the impacts of technology on the workforce. Following the presentations the participants got into small groups to discuss the issues raised by the speakers. From these discussions, a set of major issues and potential solutions were developed. The entire proceedings of the symposium have been assembled into a document which is available by request from the Department of Vocational and Technical Education at the University of Illinois.